Drainage Potential in Alberta: An Integrated Study

Summary Report

Alberta
Water Resources Commission

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An Integrated Study

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1987
Edmonton

Alberta
Water Resources Commission
Agriculture
Environment
Forestry, Lands and Wildlife

EXECUTIVE SUMMARY

In 1983, the Alberta Water Resources Commission and the Alberta Departments of Environment and Agriculture identified the need for an inventory of Alberta's agricultural drainage potential. At that time there was little information on wetlands and drainage, information that was needed for the Agricultural Land Base Study as well as for the agencies involved in managing agricultural land development programs, water and wetlands. This study was commissioned to provide an inventory of wetlands in the province and an evaluation of the feasibility of drainage, given a number of physical, environmental and economic constraints. An interdepartmental steering committee with representation from the Alberta Departments of Agriculture, Environment and Forestry, Lands and Wildlife directed the study.

Study Methods and Major Assumptions

A wetland inventory of Alberta's agricultural land base (White Zone) was completed at a reconnaissance level for this study. Seven major types of wetlands were identified, which were further differentiated using agricultural, hydrotechnical and wildlife habitat characteristics.

Five small representative watersheds (mini-basins) in central and northern Alberta were studied in detail to evaluate the feasibility of wetland drainage, given on and off-farm drainage designs and costs, agricultural production costs and benefits, wildlife related impacts and fisheries impacts. For each mini-basin three drainage scenarios were considered: drainage of all wetlands except named lakes and watercourses (total drainage), drainage of all non-permanent wetlands (partial drainage), and drainage of non-permanent wetlands and the collection of runoff from drained areas into an on-farm pond (consolidation).

The analyses of drainage feasibility assumed that:

1. Drainage costs were based on full participation by farmers (actual drainage of all identified wetlands) and control of drainage flow release at the farm level. Development of the full potential acreage for drainage would take 100 years. Costs of existing drainage works were not included. Farmers were assessed all on-farm drainage costs and no portion of the off-farm costs.

2. All agricultural production would have a market although market opportunities and economic conditions were not analysed in this study. Prices and yields were based on averages for the 10 year period, 1973 to 1982. Production costs and subsidies were based on 1982 levels. All economic and financial results are given in terms of returns to land, labour, management and existing investment. A real discount rate of 5 percent was used, which

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The analyses of drainage feasibility assumed that:

1. Drainage costs were based on full participation by farmers (assumes drainage of all identified wetlands) and control of drainage flow release at the farm level. Development of the full potential acreage for drainage would take 100 years. Costs of existing drainage works were not included. Farmers were assumed to incur on-farm drainage costs and no portion of the off-farm costs.

2. All agricultural production would have a market although market opportunities and economic conditions were not analysed in this study. Prices and yields were based on averages for the 10 year period, 1973 to 1982. Production costs and subsidies were based on 1982 levels. All economic and financial results are given in terms of returns to land, labour, management and existing investment. A real discount rate of 3 percent was used, which

reflects the difference between the interest rate charged to borrowers and the rate of inflation.

Major Study Conclusions

1. Approximately 12 million acres of wetlands are found in the agricultural area of Alberta. These wetlands represent about 20 percent of the total agricultural land base and their concentration ranges from five to 37 percent of the agricultural land in the major river basins. Over 75 percent of the wetland acreage is located in the five northern river basins: the Battle, North Saskatchewan, Beaver, Athabasca and Peace.

2. In these five basins, non-permanent wetlands (temporary slough/marsh and sheetwater) occupy approximately 2 million acres and have the highest potential for drainage. Bogs and fens (considered permanent) cover about 5.5 million acres, of which approximately half may be drainable given current technology. Other permanent wetlands (lake/pond, permanent slough/marsh and watercourse) were found in this study to be not drainable for economic and environmental reasons.

3. Drainage has a significant negative impact on wildlife, particularly where wetlands have a high habitat value. Continuation of current authorized and unauthorized drainage practices will seriously affect wildlife habitat. Drainage of the non-permanent wetlands of the five northern river basins would reduce waterfowl populations in the area by 80 percent (losses of 9.1 million ducks). This amounts to 54 percent of the total provincial population.

4. It is estimated that the present value of the costs to drain the non-permanent wetlands of the five northern river basins over a 100 year period would be approximately $1.6 billion, consisting of $330 million for on-farm drainage, $375 million for off-farm drainage works and $850 million for wildlife habitat mitigation.

5. From the farmer's perspective it is financially attractive to drain non-permanent wetlands, explaining why interest in drainage is high in these basins. On-farm consolidation was found to be financially unattractive to the farmer if he is required to pay all on-farm costs.

6. From a public perspective, when the costs of complete mitigation of habitat losses are included, drainage is economically feasible only in areas with a high proportion of sheetwater, regardless of which drainage scenario is considered. Consolidation is the lowest cost means of providing drainage and habitat mitigation.

7. From a public perspective, drainage of non-permanent wetlands is economically feasible if wildlife habitat mitigation costs are not included, erosion control costs are low or non-permanent wetlands are abundant. In cases where the erosion control costs are high or the non-permanent wetlands are few and scattered, consolidation presents the least cost means of drainage.

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Major Study Conclusions

1. Approximately 12 million acres of wetlands are found in the agricultural area of Alberta. These wetlands represent about 20 percent of the total agricultural land base and their concentration ranges from five to 27 percent of the agricultural land in the major river basins. Over 75 percent of the wetland acreage is located in the five northern river basins: the Battle, North Saskatchewan, Beaver, Athabasca and Peace.

2. In these five basins, non-permanent wetlands (temporary slough/marsh and shallow water) occupy approximately 2 million acres and have the highest potential for drainage. Bogs and fens (considered permanent) cover about 5.5 million acres, of which approximately half may be drainable given current technology. Other permanent wetlands (lake/pond, permanent slough/marsh and open water) were found in this study to be not drainable for economic and environmental reasons.

3. Drainage has a significant negative impact on wildlife, particularly where wetlands have a high habitat value. Continuation of current authorized and unauthorized drainage practices will seriously affect wildlife habitat. Drainage of the non-permanent wetlands of the five northern river basins would reduce waterfowl populations in the area by 60 percent (losses of 3.1 million ducks). This amounts to 54 percent of the total provincial population.

4. It is estimated that the present value of the costs to drain the non-permanent wetlands of the five northern river basins over a 100 year period would be approximately $1.6 billion, consisting of $430 million for on-farm drainage, $275 million for off-farm drainage works and $880 million for wildlife habitat mitigation.

5. From the farmer's perspective it is financially attractive to drain non-permanent wetlands, explaining why interest in drainage is high in these basins. On-farm consolidation was found to be financially unattractive to the farmer if he is required to pay all on-farm costs.

6. From a public perspective, when the costs of complete mitigation of habitat losses are included, drainage is economically feasible only in areas with a high proportion of shallow water, regardless of which drainage approach is considered. Consolidation is the lowest cost means of providing drainage and habitat mitigation.

7. From a public perspective, drainage of non-permanent wetlands is economically feasible if wildlife habitat mitigation costs are not included, erosion control costs are low or non-permanent wetlands are abundant. In cases where the erosion control costs are high or the non-permanent wetlands are few and scattered, consolidation presents the least cost means of drainage.

8. In the Battle and North Saskatchewan river basins, drainage of non-permanent wetlands is economically feasible only if wildlife mitigation costs are not included. In the Peace, Athabasca and Beaver basins, however, generally higher erosion control costs or more scattered non-permanent wetlands make drainage economically infeasible. Within each river basin there would, however, be economically feasible projects at a smaller scale.

9. Control of drainage flow releases at the farm level significantly reduces off-farm drainage costs by reducing peak downstream flows. Capital costs for uncontrolled flows are up to 4.6 times greater than those for controlled. Unless drainage control at upstream locations is incorporated in future programs, the economics of drainage may be seriously affected.

10. Consolidation provides an opportunity to maintain other benefits provided by wetlands such as groundwater recharge, flow regulation and water quality control. Local land owner acceptance for such an option is necessary before consolidation could be practically implemented.

Major Study Recommendations

1. It is recommended that the government include drainage in interdepartmental water management plans for each major river basin. These would include technically sound long range designs, cost effective drainage development and natural resource conservation.

° Drainage planning should be initiated on a small watershed scale within the context of multi-purpose water use planning. The cumulative effects of draining several watersheds into the same receiving channel should be considered at the river basin level.

° Hydrotechnical modelling is required to estimate runoff conditions, especially related to farm size drainage projects. More comprehensive gauging of flows is required to calibrate the models, so that peak discharges and volumes can be accurately predicted.

2. It is recommended that existing program funding be provided to drainage only after adequate integrated planning has been completed.

° The use of interagency, multidisciplinary water resource planning programs with public involvement (such as the "Sub-basin Water Management Planning Program for Northwestern Alberta") should be continued and expanded to ensure adequate representation of agricultural, wildlife, water management, transportation and local government and public interests. This process should also be incorporated in the implementation phase.

3. It is recommended that during the sub-basin drainage planning process a detailed assessment of the potential drainage benefits and wildlife habitat losses should be included. If habitat is regionally important and drainage benefits are worthwhile, then public funding for appropriate levels of habitat mitigation should be provided for in the drainage process.

4. It is recommended that funding be provided for development and testing of drainage techniques which reduce downstream impacts and provide for wildlife habitat mitigation. These techniques would include controlled or choked drainage and on-farm and regional consolidation. When the practicality of such techniques is proven, the government should provide or redirect incentives for their implementation.

- ° The potential benefits of on-farm management and control of drainage water warrant research, particularly in areas of high erosion hazard, and where only a few scattered wetlands are to be drained.

5. It is recommended that when drainage costs are high because of the need for significant erosion control, downstream damage protection or extensive networks to drain a few, isolated wetlands; then standard off-farm drainage methods should be considered not viable. In these instances, and when the agricultural potential warrants, drainage alternatives such as consolidation should be considered for public funding.

- ° The government should consider financial and other incentives to landowners for wetland retention.

6. It is recommended that funding be provided for research on the classification, drainage, agronomic development and crop production potential of bog and fen wetlands.

- ° The productivity potential and optimal management of drained non-permanent wetlands should also be investigated. This would help farmers determine where drainage is most worthwhile and provide the government with information to assist drainage in the most appropriate locations.

7. It is recommended that the drainage potential and associated salinity problems of the southern portion of the province receive further study.

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1. INTRODUCTION

Problems related to excess moisture have been a concern of Alberta's farmers since the early 1900s. Initially, it was considered less expensive to simply farm around wetlands. This attitude has changed significantly among the current generation of farmers because of higher land prices and continuing efforts to increase farm efficiency and productivity. In the intensively developed areas of the province, especially central and southern Alberta, farmers drain wetlands within cultivated fields to improve production and efficiency. In the developing agricultural regions of northern Alberta, drainage is part of the process of expanding the agricultural land base, sometimes into areas dominated by wet organic soils (bogs and fens). Agricultural development, including drainage and land clearing, has, however, caused erosion and flood control problems in many receiving channels with the consequent need for large public expenditures for remedial works in downstream locations. In addition to these problems existing drainage has also caused losses of wildlife habitat.

In 1982/83 the Alberta Water Resources Commission (AWRC) and the Alberta Departments of Environment and Agriculture identified the need for an inventory of Alberta's drainage potential and requirements. At that time there was little information on the extent of drainage, and location and number of wetlands. This information was needed for the Agricultural Land Base Study, an interdepartmental study of agricultural development opportunities in Alberta, and for the agencies managing agricultural land development programs, water and wetlands. At the request of the AWRC, Alberta Environment and Alberta Agriculture developed and submitted a drainage inventory proposal. The objectives of this study were to:

1. develop a method for estimating the amount of land with agricultural capability affected by excess moisture;

2. apply this method to Alberta's agricultural lands in order to obtain a province-wide estimate of the extent of excess moisture; and

3. identify the potential for drainage of agricultural lands in Alberta, given a number of physical, environmental and economic constraints.

The study was initiated in the summer of 1983 under the title "Inventory of Alberta's Drainage Requirements" and directed by a four-member interdepartmental steering committee which included: R. B. MacLock of Alberta Environment (Planning Division), A. L. Birch of Alberta Agriculture (Resource Planning Division), B. Paterson of Alberta Agriculture (Irrigation and Conservation Division) and R. G. Weatherill of Alberta Forestry, Lands and Wildlife (Fish and Wildlife Division).

The steering committee provided overall direction, with contractors hired to provide daily management of the study, coordinate consultant inputs

and compile this report. Twelve consulting firms were contracted to complete specific portions of the project. The steering committee also benefited from the advice and expertise of staff members of the participating departments, detailed in Appendix A.

The majority of the funding for this study was provided by the AWRC with additional resources from Alberta Environment, Alberta Agriculture and Alberta Forestry, Lands and Wildlife.

The study was completed in three phases, in accordance with the objectives stated above:

1. Phase I - developed and tested methods which could be used to complete a wetland inventory. Six different inventory methods were examined to determine the most appropriate for the wetland inventory.

2. Phase II - completed a wetland inventory of a sampling of the White Zone area of Alberta, which is that portion of the province available for agricultural settlement. The wetlands of 65 randomly selected townships were classified and measured using aerial photographs taken for this study. The results were extrapolated to obtain estimates of the extent and nature of wetlands in Alberta's agricultural area.

3. Phase III - developed, tested and implemented methods to determine drainage feasibility. A multi-disciplinary team of six consulting firms studied five small basins in central and northern Alberta to determine the benefits, costs and constraints of drainage.

This report describes the study, its results, recommendations and policy implications and provides relevant appendix material. The title reflects the study process and scope. A listing of the reports produced for this study and where they may be reviewed appears in Appendix A.

This study is the first in the history of water management in Alberta to provide a wetland inventory combined with an interdisciplinary assessment of drainage potential. This includes consideration of hydrology and hydraulics, agronomy, drainage engineering, wildlife, fisheries and economics.

2. WETLAND INVENTORY

2.1 Phase I

2.1.1 Introduction

A method that would yield reliable information within the time and budget limits of this study had to be selected before a reconnaissance level wetland inventory could be initiated. Phase I consisted of studies which developed a wetland classification system and applied it to seven diverse study areas. The results of these studies were used to identify an appropriate method for the Phase II inventory.

2.1.1.1 Wetland Classification System. The wetland classification system developed for Phase I was designed to identify features relating to agricultural potential, wildlife habitat value and hydrological significance. It also was applicable to different data sources, required minimum ground-truthing and was easily converted to a computerized database. The wetland classification system developed for Phase I was derived from those described by Stewart and Kantrud (1969) and Millar (1976).

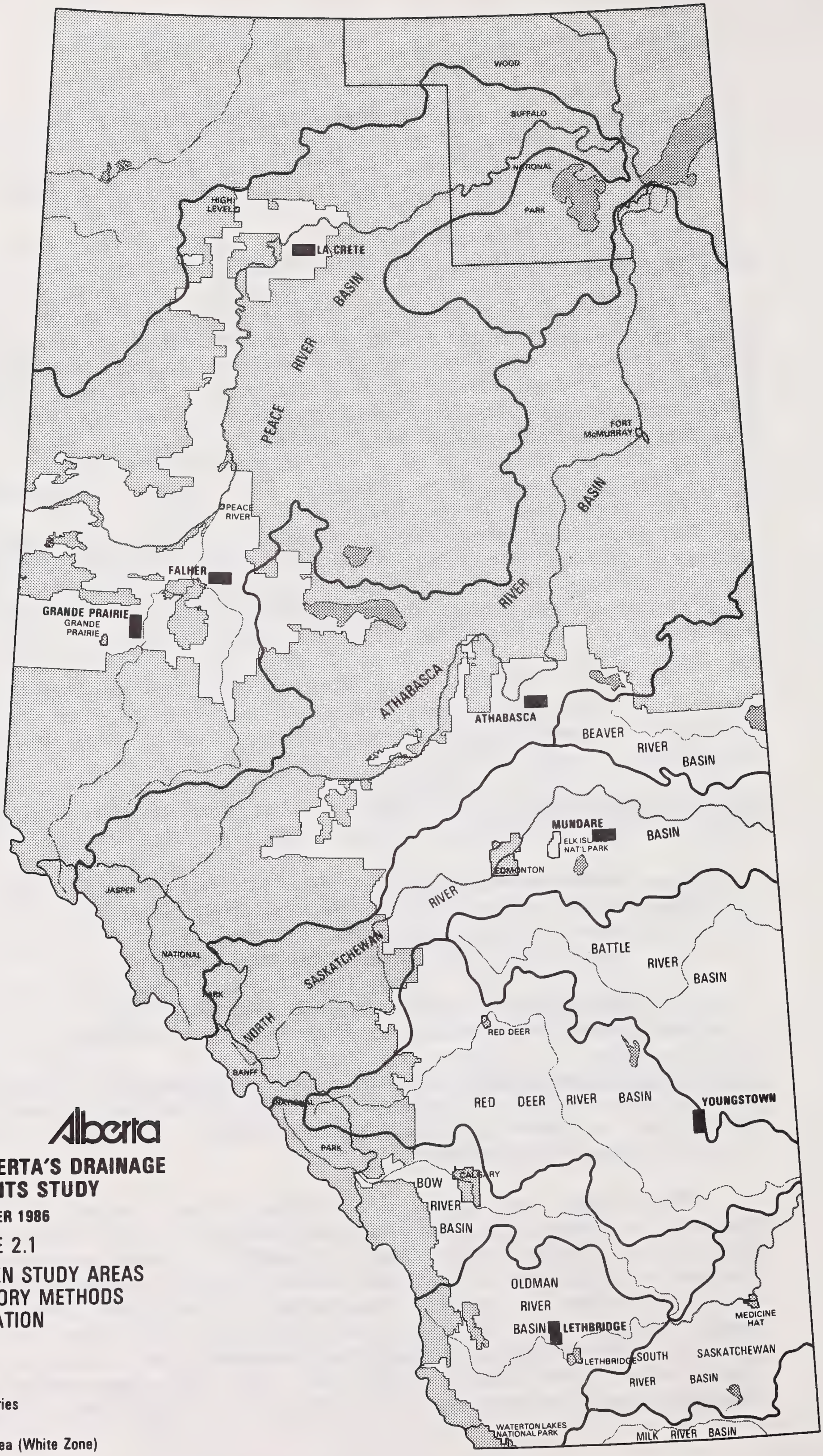
The system contains six different descriptors including: wetland type, permanency, vegetation cover, watershed position, adjacent land use and chemistry (Intera 1984a). A definition of each descriptor appears in Appendix B.

2.1.1.2 Data Sources. The Phase I studies involved the application of the Phase I wetland classification system to six types of data:

1. current colour aerial photography;
2. current colour infrared (CIR) aerial photography;
3. Landsat satellite imagery;
4. historic black and white aerial photography;
5. available maps: Canada Land Inventory waterfowl and agriculture capability maps and provincial soils maps; and
6. county and municipal farmland assessment sheets.

2.1.1.3 Study Areas. Seven study areas representing different regions, wetland and agricultural conditions were selected for testing each data type. These areas are shown on Figure 2.1 and listed in Table 2.1. A description of each is found in Appendix B.

Three areas are located in the Peace River region of northwestern Alberta. La Crete in the north is characterized by large areas of uncleared bogs and fens; Falher, farther south, is mostly cultivated and has sheetwater (temporary ponding) as a significant wetland problem; and the Grande Prairie area has a variety of wetland types within its undulating terrain. In east-central Alberta the Athabasca study area, like La Crete, is considered typical of agricultural areas undergoing expansion onto lands dominated by organic soils. The Mundare study area near Vegreville exhibits undulating topography and solonetzic soils. The Youngstown study area in southeastern



Alberta

INVENTORY OF ALBERTA'S DRAINAGE REQUIREMENTS STUDY

SEPTEMBER 1986

FIGURE 2.1

LOCATION OF SEVEN STUDY AREAS PHASE I INVENTORY METHODS EVALUATION

Study area

River basin boundaries

Agricultural land area (White Zone)

PRODUCED BY THE RESOURCE EVALUATION AND PLANNING DIVISION, ALBERTA FORESTRY, LANDS AND WILDLIFE, 1986.

Table 2.1

SUMMARY OF PHASE I INTERPRETATION ACCURACIES FOR AERIAL PHOTOGRAPHY

PHASE I STUDY AREA	WETLAND PARAMETERS						AVERAGE Percentage Accuracy
	TYPE	PERMANENCY	VEGETATION	POSITION	CHEMISTRY	DISTURBANCE	
	(percent accuracy)						
LA CRETE							
Colour	90	78	82	89	88	90	**86**
Colour Infrared	79	72	50	81	66	80	**72**
FALHER							
Colour	94	54	82	94	94	92	**85**
Colour Infrared	88	58	59	82	89	65	**74**
GRANDE PRAIRIE							
Colour	88	77	92	94	99	99	**92**
Colour Infrared	81	48	68	83	91	82	**76**
ATHABASCA							
Colour	92	90	80	98	94	97	**92**
Colour Infrared	85	62	56	84	65	78	**72**
MUNDARE							
Colour	96	64	89	96	96	94	**89**
Colour Infrared	79	51	55	56	76	54	**62**
Black & White Wet	81	38	47	63	69	44	**57**
Black & White Dry	82	37	45	62	79	49	**59**
YOUNGSTOWN							
Colour	98	63	92	98	94	95	**90**
Colour Infrared	72	31	58	58	58	51	**55**
LETHBRIDGE							
Colour	53	49	85	81	51	82	**67**
Colour Infrared	52	50	77	71	54	73	**63**
Black & White Wet	49	34	41	45	53	51	**46**
Black & White Dry	37	26	26	43	50	59	**40**
AVERAGE							
Colour	87	68	86	93	88	93	**86**
Colour Infrared	77	53	60	74	72	69	**68**
Black & White Wet	65	36	44	54	61	48	**52**
Black & White Dry	60	32	36	53	65	54	**50**

Wet - Photography from a "wet" year
Dry - Photography from a "dry" year

SOURCE: Intera Technologies Ltd. (1984a), p. 88.

Alberta is natural rangeland over half its area, typical of the semi-arid prairie zone. The Lethbridge study area, with irrigation and dryland farming, is representative of much of southern Alberta.

2.1.2 Study Methods and Results

2.1.2.1 Aerial Photography. Colour and CIR photographs taken in the fall and early winter of 1983 were used for the Phase I aerial photography studies. Standard air photo interpretation techniques were used to prepare maps, at a scale of 1:20,000, showing the identified wetland areas. In addition, black and white photographs from wet and dry years for three of the seven study areas were also interpreted and mapped. The photography used is listed in Appendix B.

Wetland reference maps of each study area were prepared using field observations and current colour photographs. These maps served as the standard for assessing the accuracy of each photographic type (colour, CIR and black and white). In addition, the data for these maps was computerized to facilitate the statistical comparison.

The results presented in Table 2.1 indicate that interpretation of colour photographs was the most accurate, with an average accuracy rate of 86 percent, followed by CIR photography, which averaged 68 percent. Black and white photography was the least accurate. The lower accuracy rate for CIR is misleading, however, because the infrared photography used in this study was of poor quality and was taken after the growing season. It is known that CIR photography provides much more information than colour photography on vegetation and open water if it is taken during the growing season (Intera 1985).

For all photographic types some parameters were more accurately interpreted than others. Generally the accuracy was greatest for watershed position with the following decreasing order for the other major parameters: wetland type, adjacent land use, chemistry, vegetation and permanency. There was little variation related to geographic location but saline seeps which occur predominantly in the southern areas of the province were the most difficult to identify.

2.1.2.2 Landsat. Landsat satellite images were also tested. For this study, late summer or fall coverage representing green (Band 4), red (Band 5) and infrared (Band 7) reflectance were used. This imagery is similar to the CIR photography except that each Landsat image is at a much smaller scale and covers a much larger area, about 13,000 square miles (Intera 1984b). Images recorded in 1983 were examined for all study areas (Appendix B). In addition, examples for a wet and/or dry year for four of the areas were also used. All were computer enhanced so that wetlands were more easily identified.

The enhanced images were interpreted using the same classification system and procedures as the aerial photographs. The wetland information was then transferred onto 1:50,000 scale NTS topographic base maps. These maps were compared with the wetland basemaps prepared for the aerial photography study (section 2.1.2.1).

The results presented in Table 2.2 indicate that the interpretation accuracy for Landsat data using the classification system outlined was low, ranging from a minimum of 13 percent for Mundare to a high of 58 percent for the Athabasca study area. The higher rate in the Athabasca area was due to the presence of large bogs and sloughs. The greatest identification difficulty was for small wetlands in cultivated areas because they could not be resolved on the Landsat image. Saline areas were also consistently difficult to distinguish. The accuracy of mapping wetland characteristics generally followed the same order as for aerial photographs. Mapping was more accurate for wet years than for dry years.

2.1.2.3 Canada Land Inventory Maps and Farm Assessment Sheets. Canada Land Inventory (CLI) maps present an evaluation of the land's capability for different types of resource production. In this analysis, each study area was delineated and classified on corresponding CLI land capability maps for waterfowl production and soil capability for agriculture, and provincial soils survey maps (Kerr and Young 1984). These maps were at three different scales: 1:250,000, 1:63,360 and 1:50,000. Only a few wetland type descriptors were used because of the general level of detail of these maps, and virtually no information could be obtained pertaining to the other five characteristics of the classification system The information was transferred to 1:20,000 base maps, the wetland areas planimetered and the data stored in a computer database.

Wetland areas represented on the CLI and soil survey maps were not significantly different except that bog/fen areas were larger on the soils maps. Little detail was obtained from CLI maps. Only a few categories of wetlands were discernible from the waterfowl capability maps (lake/pond, complex and non-wetland). The 1:63,360 scale soil capability and provincial soils maps provided slightly more differentiation than all scales of waterfowl capability maps and the smaller scale soil capability maps.

Information from approximately 2,000 farm assessment sheets, for four of the seven areas was compiled and summarized (Kerr and Young 1984). A farm assessment sheet is a record of the tax assessment for each quarter section of private land. It consists of a sketch map showing land uses, accompanied by an evaluation of the agricultural value of each designated area. The assessment sheets are reviewed at least every eight years. Any references to wetland areas or non-arable land were recorded. The many wetland descriptors used by the assessors were then categorized as one of seven wetland types: slough/marsh, bog/fen, seep, lake/pond, watercourse, wet pasture and complex (groups of small wetlands).

Beyond identifying the general wetland type and permanency, little information could be obtained to describe each wetland in terms of vegetation, watershed position, chemistry and adjacent land use. The accuracy rate was also low because of the variety and inconsistency of description, even within the same township.

The farm assessment sketch maps recorded significantly smaller wetland areas than the soil capability maps for agriculture and the provincial soils maps. This comparison is difficult to assess because of the great differences in detail provided by these map types.

Table 2.2

SUMMARY OF PHASE I INTERPRETATION ACCURACIES FOR LANDSAT IMAGERY

PHASE I STUDY AREA	WETLAND PARAMETERS						AVERAGE Percentage Accuracy
	TYPE	PERMANENCY	VEGETATION	POSITION	CHEMISTRY	DISTURBANCE	
	(percent accuracy)						
LA CRETE							
1983	57	48	22	54	30	41	**42**
1981 (dry)	57	39	28	57	43	48	**45**
FALHER							
1983	38	15	23	44	44	26	**32**
GRANDE PRAIRIE							
1983	43	13	13	39	52	41	**34**
1982 (wet)	33	17	21	29	38	22	**27**
ATHABASCA							
1983	69	57	50	79	47	72	**58**
MUNDARE							
1983	36	10	28	28	36	12	**25**
1981 (dry)	25	8	12	2	22	8	**13**
1973 (wet)	30	12	22	6	32	14	**19**
YOUNGSTOWN							
1983	38	23	27	31	15	23	**26**
LETHBRIDGE							
1983 CS	29	18	59	71	35	35	**41**
1983 EN	7	0	47	60	66	33	**36**
1977 (wet)	29	18	18	53	29	41	**31**
AVERAGE	44	26	32	49	37	36	**37**

Wet - Photography from a "wet" year
Dry - Photography from a "dry" year

SOURCE: Intera Technologies Ltd. (1984b), p.45.

2.1.3 Conclusions

Six different inventory methods were evaluated. Three of these, Landsat, CLI and farm assessment sheets, were considered unacceptable because they did not yield the type or level of detail required for this study. It is noted that Landsat could be a useful and inexpensive tool to monitor changing wetland conditions on a wide-scale basis.

The results indicate that of the three aerial photographic types, colour was the most accurate. CIR photography was somewhat less accurate, and much of this difference was attributed to the poor quality of the photographs and the fact that they were taken outside the growing season. Based upon previous research, it was known that CIR photography of good quality taken during the growing season would be more accurate than colour photography (Intera 1985). It was also known that CIR photography taken during the growing season would record conditions relating to wetland type and permanency, as well as aquatic and upland vegetation which are important for wildlife. It was decided therefore, that the Phase II wetlands inventory would be conducted during the growing season using CIR photography. Quality control measures to ensure high quality photography were recommended.

Some descriptors of the Phase I classification system had proven unnecessary and others required additions. Revisions reflecting this experience were made to the classification system used in the Phase II inventory. These included:

1. reducing the number of permanency classes from five to three;
2. adding a Form category to include such descriptors as deep depression, shallow depression, channel basin and sloping;
3. reducing the Chemistry category to saline or non-saline;
4. adding a complex designation for groups of small waterbodies; and
5. distinguishing between wetland and upland vegetation cover.

2.2 Phase II: Wetland Inventory and Township Analysis

2.2.1 Introduction

The purpose of Phase II was to produce a reconnaissance level inventory of the wetlands of Alberta's White Zone. The inventory data would be used in conjunction with the results of the Phase III mini-basin studies to determine the costs and implications of drainage in Alberta.

Phase II involved selecting and photographing townships throughout the agricultural regions of the province, selecting a sub-sample of these and

identifying and classifying their wetlands. This data was compiled on a computer and the results extrapolated to the White Zone.

2.2.2 Methods

The photographs used for this study were taken during the summer and fall of 1984. A selection of 325 townships (Appendix C) within the White Zone of Alberta was photographed at a scale of 1:50,000. CIR film was used to photograph 271 townships during the growing season, summer and early fall. Colour film was used to photograph 54 townships in late September, when CIR would not provide as much vegetation detail as colour film.

A random sample of 65 of the 325 townships photographed, shown in Figure 2.2, was interpreted using a modified version of the Phase I classification system, as listed in Table 2.3. The legend includes nine factors: wetland type, permanency, wetland area ground cover, upland ground cover, watershed position, form, disturbance (nature of adjacent land use), water chemistry and complex. All terms are defined in Appendix C.

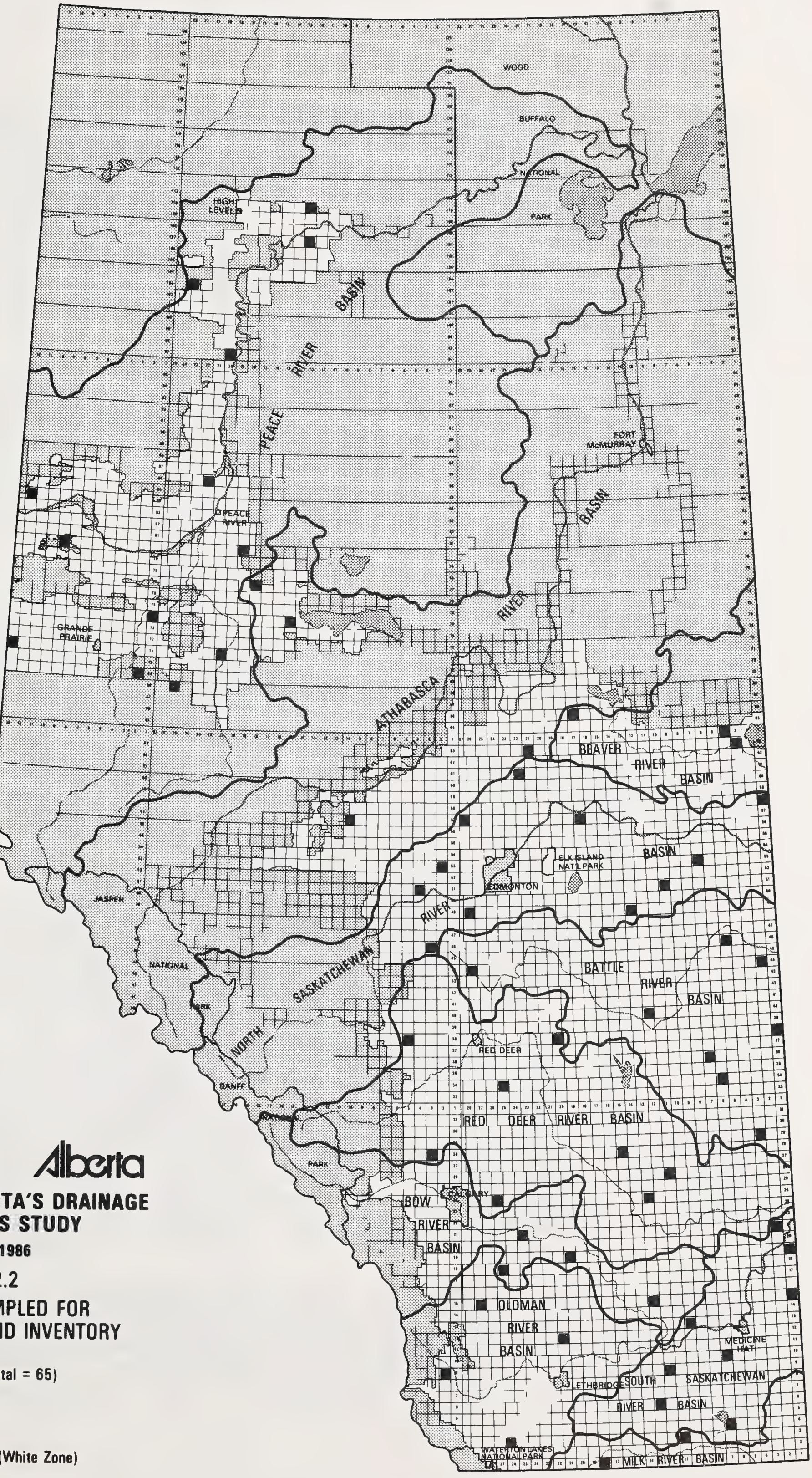
The factors considered most important for this level of wetland inventory were wetland type and permanency, which were combined to produce seven wetland categories. The other descriptors are important in the more detailed analyses of drainage feasibility.

NON-PERMANENT WETLANDS

1. **Non-permanent slough/marsh:** Wetland in a depression where surface drainage is obstructed, with less than 50 percent of the area open water. Surface water is not always present; the area is usually dry for part of the growing season, especially in late summer and fall.
2. **Sheetwater:** Areas of relatively flat, non-sloping terrain that are periodically inundated by shallow, open water that persists for short time periods.
3. **Seep:** Wet areas resulting from groundwater discharge at the soil surface.

PERMANENT WETLANDS

4. **Permanent slough/marsh:** Same description as for non-permanent slough/marsh except that surface water is present year round or climax vegetation is present.
5. **Lake/pond:** Permanent body of open water.
6. **Bog/fen:** Areas composed mainly of peat or sedge and organic materials.
7. **Watercourse:** Channel for running water and adjacent floodplain.



Alberta

INVENTORY OF ALBERTA'S DRAINAGE REQUIREMENTS STUDY

SEPTEMBER 1986

FIGURE 2.2

TOWNSHIPS SAMPLED FOR PROVINCIAL WETLAND INVENTORY

■ Townships sampled (total = 65)

—— River basin boundaries

☐ Agricultural land area (White Zone)

PRODUCED BY THE RESOURCE EVALUATION AND PLANNING DIVISION, ALBERTA FORESTRY, LANDS AND WILDLIFE, 1986.

Table 2.3

REVISED CLASSIFICATION SYSTEM USED FOR WETLANDS INVENTORY OF ALBERTA - PHASE II*

TYPE	PERMANENCY	WETLAND GROUND COVER	UPLAND GROUND COVER	WATERSHED POSITION	FORM	DISTURBANCE	CHEMISTRY	COMPLEX
P Slough/Marsh	t Temporary	0 Bare soil/rock	0 Bare soil/rock	.I Isolated	d deep depression	U Undisturbed	s saline	1 20 - 50 %
S Seep	s Seasonal	1 Herbaceous	1 Herbaceous	.O Overflow	h shallow depression	D Drainage	n non-saline	2 50 - 80 %
B Bog/Fen	p Permanent	2 Shrub	2 Shrub	.C Channel	c channel	I Irrigation		
L Lake/Pond		3 Tree-hardwood	3 Tree-hardwood	.T Terminal	b basin	M Impoundment		
H Sheetwater		4 Tree-coniferous	4 Tree-coniferous		s sloping	T Tillage/grazing/ mowing		
W Watercourse		5 Aquatic	5 Herbaceous-shrub			R Resource Extraction		
		6 Cultivated crop	6 Herbaceous-tree			C Cleared/regrowth		
		7 Improved pasture/forage	7 Shrub/tree			O Other		
		8 Open Water	8 Cultivated crop/ summerfallow					
			9 Improved pasture/forage					
			N Not applicable					
N Non-arable								

EXAMPLE

Pt1. OhDS2		Lp8.TbM	
	P= slough/marsh		L= lake/pond
	t= temporary		p= permanent
	1= herbaceous cover		8= open water
	.O= overflow position		.T= terminal position
	h= shallow depression form		b= basin form
	D= drainage works present		M= impoundment
	saline		
	2= 65% of area outlined		

The last two spaces are default positions for "non-saline" chemistry and 80 - 100 % of the outlined area as wetland.

All terms are defined in Appendix C.

* SOURCE: Intera Technologies Ltd. (1985), p.9.

Eighteen sections of each township were interpreted, based on a random sampling of pairs of sections. A 1:30,000 scale map for each township was produced showing the classified wetlands for the 18 sections interpreted. Ground truthing of eight townships was carried out in the late fall of 1984 and spring of 1985, to refine the interpretation methods and familiarize interpreters with field conditions. The wetland maps were digitized using a computer program specifically developed for this study. Examples of data produced for each township and a digitized map are found in Appendix C.

Because late summer and early fall photographs were used for this inventory, the extent of sheetwater in the northern townships was underestimated since it usually occurs in the spring as a result of snowmelt. Those townships likely to have sheetwater conditions, therefore, were reviewed using colour or CIR photographs. Six townships were subsequently studied using spring black-and-white photography at a 1:60,000 scale. Their sheetwater areas were identified and added to the inventory.

2.2.3 Results of Phase II Inventory

The data from the Phase II interpretation represent a sampling of 1.2 percent of the province's agricultural land base. They indicate that wetlands occupy about 20 percent of the land area surveyed. As illustrated in Figure 2.3, almost half the wetlands in Alberta are bog/fens and one-third are classified as slough/marsh.

The results of the interpretation are presented in Figures 2.4 to 2.6, which illustrate the changes in wetland density from south to north for each wetland type. Maps showing the results for the townships sampled appear in Appendix C.

Figure 2.4 presents the distribution of wetlands in the province, expressed as a percentage of the land area surveyed. The highest density of wetlands is found in northern Alberta, where up to 60 percent of the land area is affected. The wetlands are mostly bog/fen, which as mentioned above, are the most abundant wetland type in the province.

Figure 2.5 presents the results for non-permanent wetlands, non-permanent slough/marsh, sheetwater and seep.

Generally, the highest density of non-permanent slough/marsh is found in central Alberta; with 10 to 20 percent of the land area affected. The density of slough/marsh tends to diminish to the north and south from central Alberta. This category represents the second most abundant wetland type encountered in the inventory, accounting for about 28 percent of the total wetland area.

Only four townships, all located in northern Alberta, exhibited sheetwater. The total sheetwater acreage of this inventory represents only 2 percent of the total wetland acreage measured. Because sheetwater areas are very difficult to identify unless the photography is taken during spring snowmelt or shortly after a significant rainfall, this estimate is

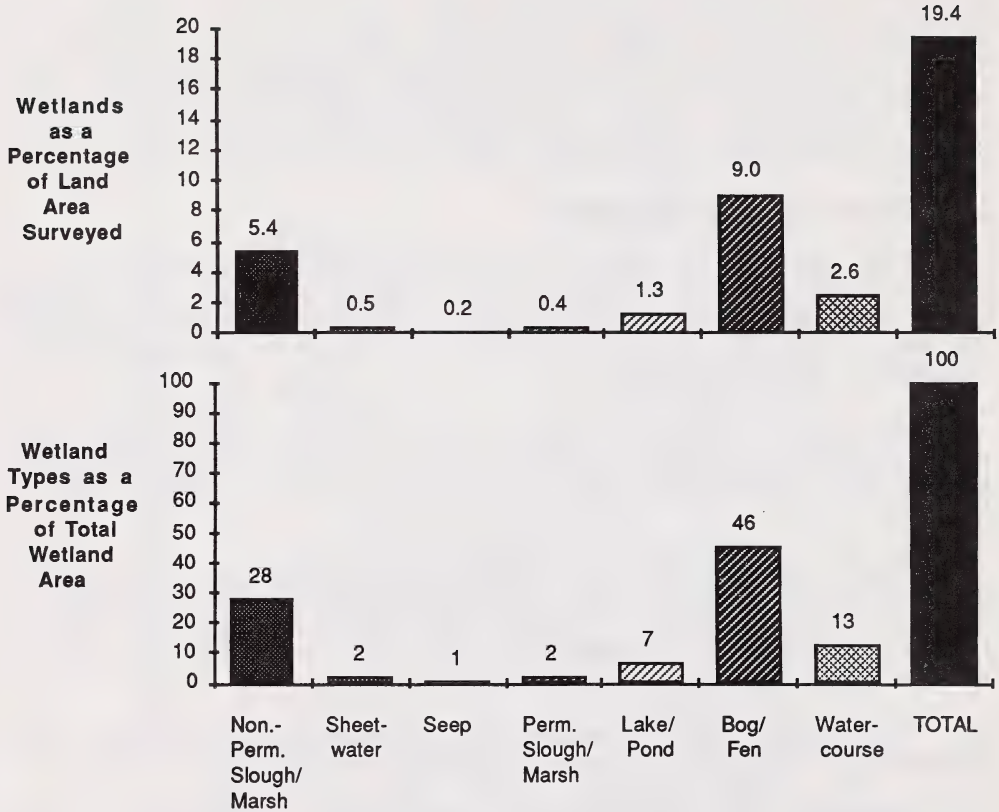


Figure 2.3 WETLAND PROPORTIONS BASED ON SAMPLE OF 65 TOWNSHIPS

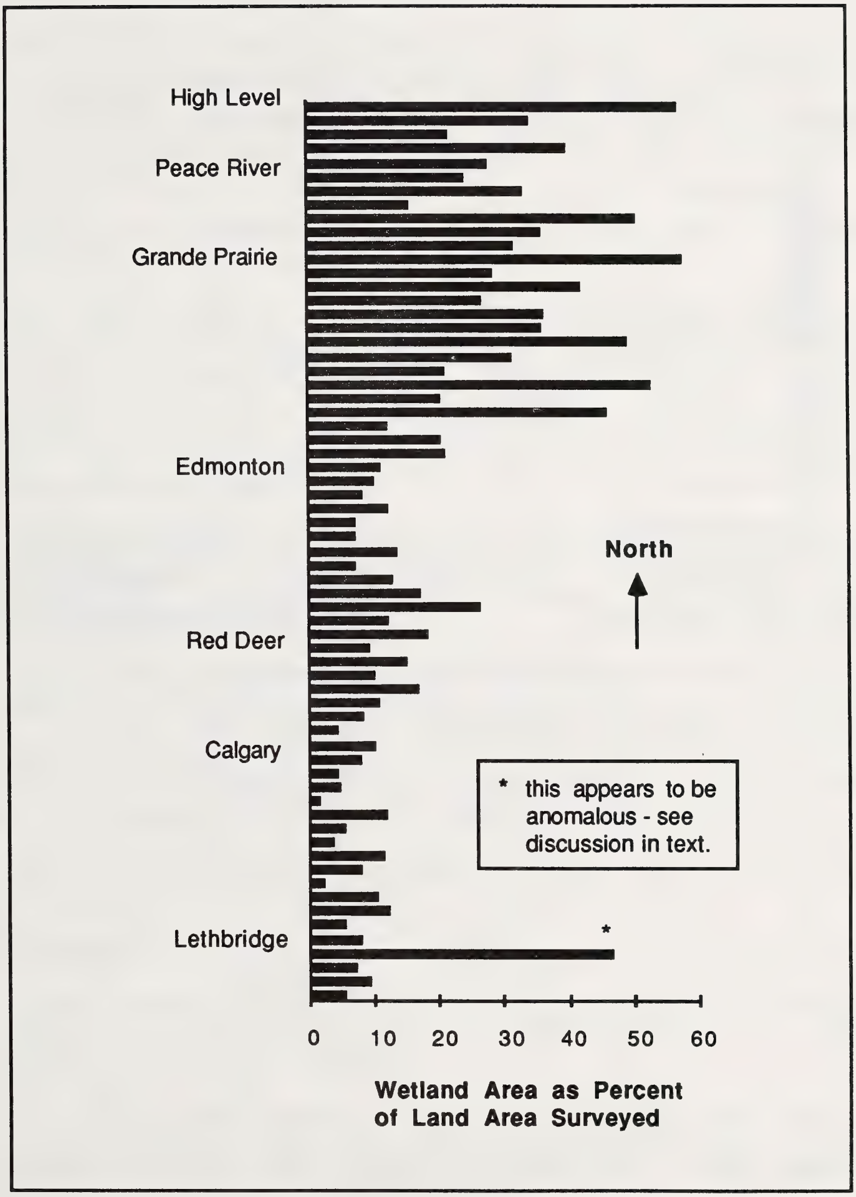


Figure 2.4 TOTAL WETLAND DENSITY - PHASE II INVENTORY

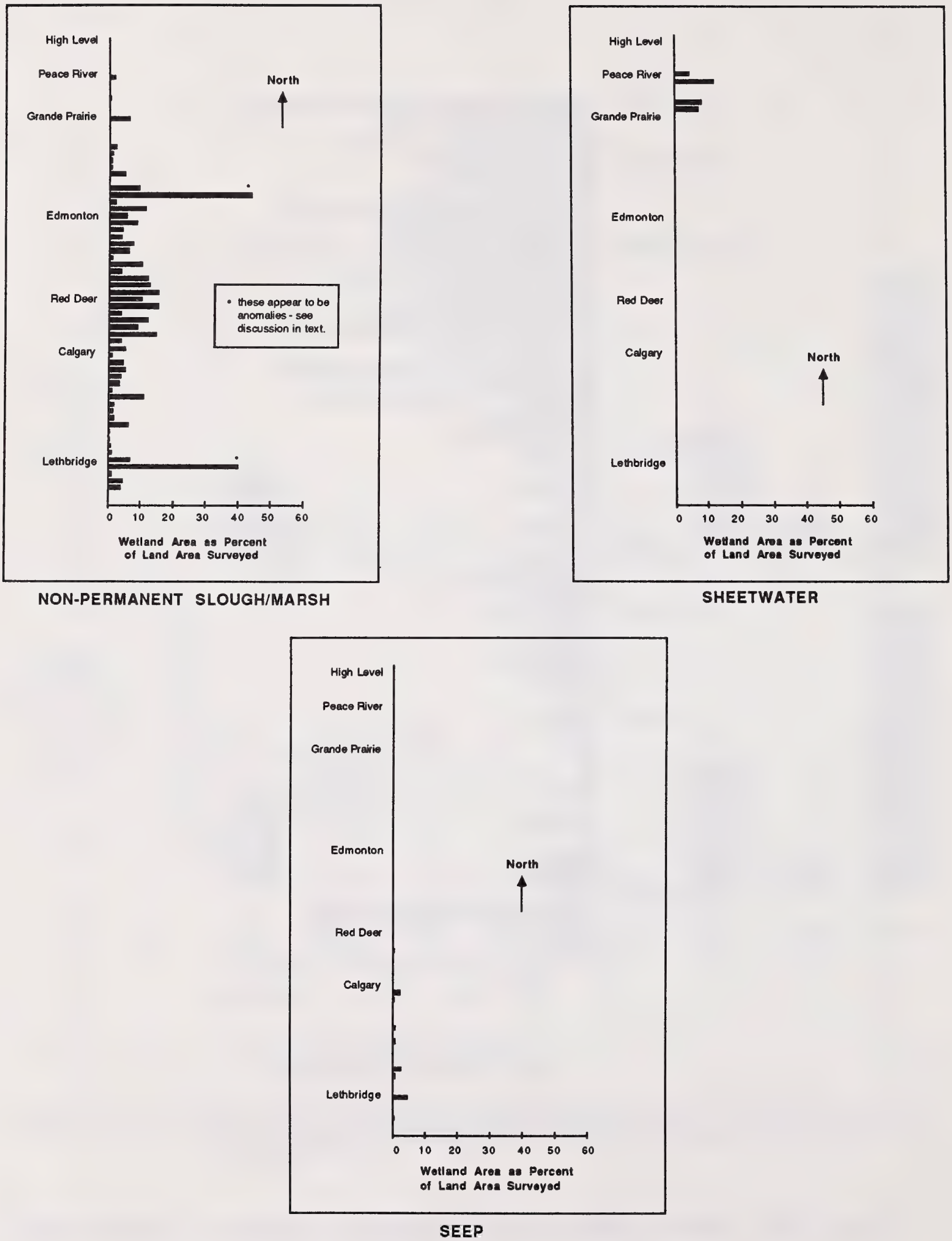


Figure 2.5 NON-PERMANENT WETLAND DENSITY - PHASE II INVENTORY

considered low. Based on the areas identified, sheetwater would be expected on cultivated lands with little overall slope.

Seeps are found only in central and southern Alberta where they account for less than 5 percent of the land area surveyed. The total area of seeps identified in this inventory is less than one percent of the total wetlands measured. The Phase I studies found that seeps were consistently difficult to identify using aerial photography, so this is considered an underestimate.

Figure 2.6 presents the results for permanent wetlands; permanent slough/marsh, lake/pond, bog/fen and watercourse.

The highest density of permanent slough/marsh was found in the Lakeland area of north-eastern Alberta, where it constitutes less than 5 percent of the township area surveyed. There was little found in central Alberta, and none were identified in southern Alberta. Permanent slough/marsh accounts for only 2 percent of the total wetland acreage surveyed. This estimate may be low because of the dry conditions in 1984 and preceeding years.

The highest density of lake/pond is in the northeastern portion of the agricultural area, where about 10 percent of the land area is occupied by this wetland type. Lake/pond accounts for about 7 percent of the total wetland area measured in this study.

Large areas of bog/fen, affecting more than 30 percent of the land area surveyed, are found in northwestern Alberta (Peace and Athabasca river basins). Here it is the predominant wetland type accounting for more than half the wetland acres. There are a few townships with bog/fen in central Alberta and none in southern Alberta. Bog/fen represents the most abundant wetland type encountered in this study; about 46 percent of the total.

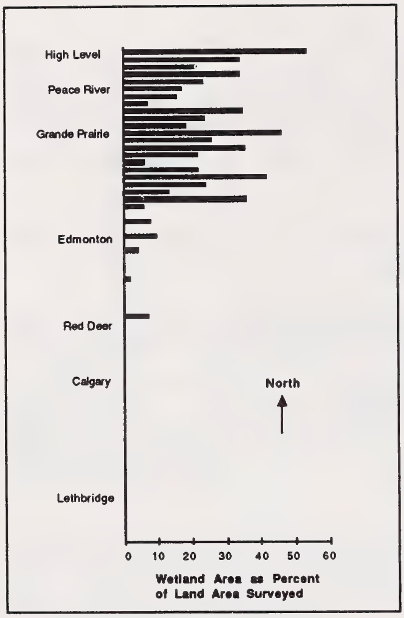
The watercourse category accounts for about 13 percent of the total wetland area measured.

2.2.4 Discussion

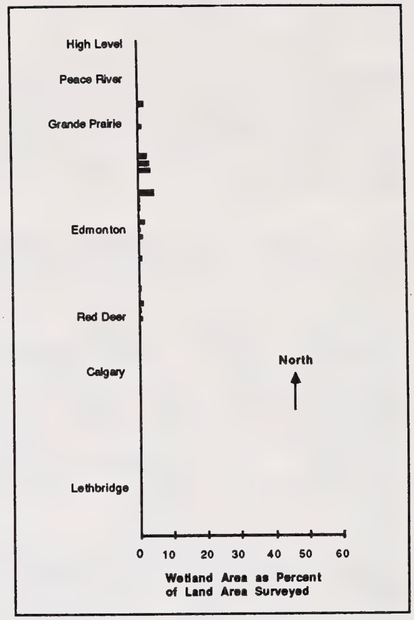
Several factors affect the accuracy of this inventory, including the type and timing of the photography, number and location of sampled townships and interpretation methods.

1. Photography. Ideally all the photography should have been of one type, acquired during a brief period within the growing season. Logistical considerations precluded this and the photography was of two types taken over a period of two and a half months.

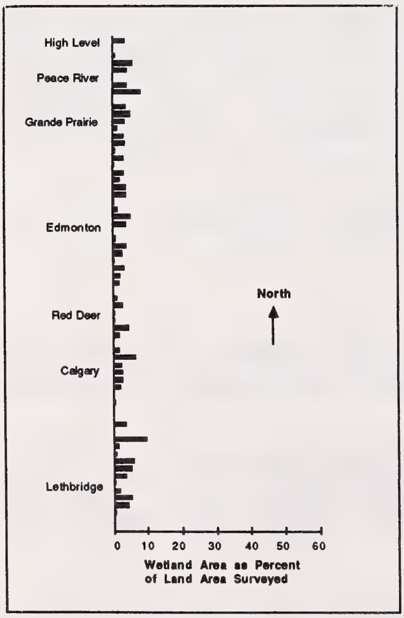
Aerial photographs from only one year were used for this inventory. Therefore, it is important to recognize how typical the wetland conditions were. For the most part, 1983 and 1984 were very dry years throughout Alberta. The data generated from this inventory underestimate the extent of wetlands especially in the non-permanent categories. It may be difficult to detect these wetland areas because there is little permanent perimeter



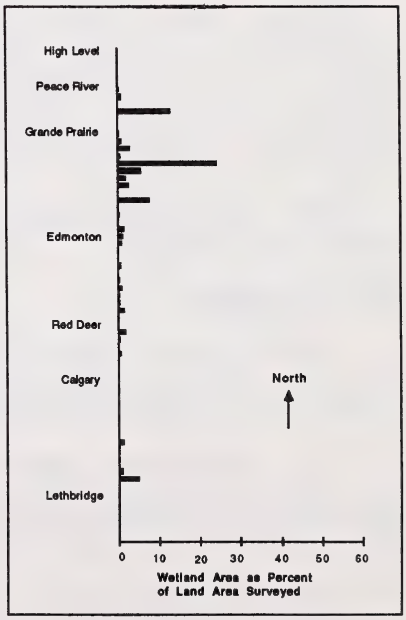
BOG/FEN



PERMANENT SLOUGH/MARSH



WATERCOURSE



LAKE/POND

Figure 2.6 PERMANENT WETLAND DENSITY - PHASE II INVENTORY

vegetation to indicate where they have existed. In contrast, there would be little change in wetland areas designated as bog/fen, permanent slough/marsh or lake/pond because they have a well defined perimeter which remains distinct even if the internal water level has dropped or disappeared.

The photographs were not suitable for accurate detection of seeps. Additionally, because of timing, they were not appropriate for identifying sheetwater, which tends to occur earlier in the year or in wet years. Black-and-white spring photography was a valuable supplementary data source for evaluating this wetland type.

2. Sampling of Townships. Sixty-five townships were randomly selected for this wetland inventory. General trends in wetland distribution and density were observed from north to south with the exception of two townships which exhibit unusually large wetland areas for the region in which they are found. These two townships (Township 4, Range 7, West 4th Meridian, south of Medicine Hat and Township 57, Range 17, West 4th Meridian near Redwater) have wetland densities of 40 percent or greater whereas the average for surrounding townships is about 10 percent. These anomalies were omitted from the extrapolation analysis.

3. Interpretation Methods and Ground Truthing. While in the Phase I studies the interpretation accuracy using CIR photography averaged 68 percent, this was for fall photos of poor quality. Because most of the Phase II CIR photography was taken during the growing season (when it provides the greatest resolution of vegetation types), the accuracy rate for this study is considered significantly better. The interpretation was judged on the basis of field checks to be reasonably accurate.

2.3 Phase II: River Basin and Provincial Wetland Extrapolation

Extrapolating the results of the Phase II inventory to the provincial scale was necessary to satisfy the objectives of the study. In addition, an extrapolation from the Phase II inventory results was undertaken at the river basin scale to facilitate the province's approach to managing water on a river basin or watershed basis.

2.3.1 Methods

The digitized information obtained from the interpretation of the 65 townships was tabulated and analyzed to produce wetland estimates for the river basins, the major water management units of the province. This involved the following steps:

1. Totalling the wetland areas for the 18 sections of each township on the basis of wetland type, permanency and size and calculating the variance of each total.

2. Computing the estimated wetland acreages for the agricultural area of each river basin by extrapolation of the data from the

townships sampled within its boundary. This was achieved by using a multiplier factor which reflected the proportion of the river basin area actually sampled (see second last column of Table 2.4).

3. Wetland estimates for the agricultural area were derived by adding the results for all 10 river basins.

The standard error, relative error and confidence limits were computed for the estimates of each wetland type for each river basin (Harrison 1986).

2.3.2 Results

The provincial wetland estimates are summarized in Table 2.4. As shown, the agricultural area of Alberta is estimated to have a total of 12.1 million acres of wetlands, representing about 20 percent of the land area. The largest category is bog/fen with about 5.6 million acres, followed by non-permanent slough/marsh with 3.3 million acres and watercourse with about 1.6 million acres. Information on the confidence limits of these estimates appears in Appendix C.

The extrapolated results are based on the sampling of a small portion of the agricultural land of each river basin, ranging from a high of 1.8 percent for the Oldman to a low of 0.9 percent for the South Saskatchewan and Athabasca river basins (Table 2.4).

Figure 2.7 presents the wetland area totals for each river basin. The Peace River basin has the greatest wetland acreage, about 3.8 million acres, followed by the Athabasca and North Saskatchewan river basins each with almost 2.0 million wetland acres. The Beaver, Battle and Red Deer river basins each have about one million acres, the South Saskatchewan about half a million and the Bow about a quarter million. The Oldman and Milk river basins each have almost 100,000 acres of wetlands. A more detailed discussion of the distribution of wetland types within the five northern river basins appears in Section 4.2.

Figure 2.8 illustrates that wetland density ranges from a high of over 30 percent of the agricultural land area of each basin in the north to less than 10 percent in the southern basins. Over 75 percent of the wetlands are found in the five northern river basins.

As well as a significant change in wetland density from north to south, there is a change in dominant wetland type (Table 2.4). The three northern basins are dominated by large areas of bog/fen, with much smaller acreages of sheetwater and/or permanent wetlands. In the North Saskatchewan River basin, non-permanent slough/marsh and bog/fen are the most prevalent wetland types, with non-permanent slough/marsh being more abundant. Most of the wetlands of the Battle River basin are non-permanent slough/marsh. All the southern basins have non-permanent slough/marsh or watercourse as the predominant wetland type, and smaller areas of seep and permanent sloughs or ponds.

The wetland estimates generated by this study are considered acceptable for a reconnaissance level inventory. The reader is cautioned to

Table 2.4

ESTIMATED ACREAGE OF WETLANDS IN THE AGRICULTURAL REGIONS OF ALBERTA (by wetland type and river basin)

RIVER BASIN	BASIN AREA*	Non-Permanent Slough/ Marsh	Sheet-water	Seep	TOTAL NON-PERMANENT	Permanent Slough/ Marsh	Lake/ Pond	Bog/Fen	Water-course	TOTAL PERMANENT	TOTAL	% of Basin Occupied by Wetland	Percentage of Basin Sampled
	(thousands of acre)												
Peace	11,244	75	206	0	281	14	71	3,062	389	3,536	3,817	33.94%	1.33%
Athabasca	5,391	52	110	0	162	84	208	1,460	82	1,834	1,997	37.04%	0.85%
Beaver	2,327	37	0	0	37	50	258	406	59	772	809	34.78%	1.49%
North Sask.	8,663	803	0	0	803	91	114	563	246	1,015	1,818	20.98%	1.46%
Battle	8,317	830	0	6	836	29	57	0	87	174	1,010	12.14%	1.11%
SUB-TOTAL	35,942	1,797	316	6	2,119	269	707	5,490	864	7,331	9,450		
Red Deer	10,760	798	0	31	829	26	38	86	314	465	1,293	12.02%	0.96%
Bow	4,124	223	0	25	248	0	16	0	30	46	294	7.13%	1.12%
South Sask.	4,516	376	0	55	431	3	42	0	162	207	637	14.11%	0.85%
Oldman	5,391	73	0	10	83	1	12	0	180	193	276	5.12%	1.79%
Milk	1,544	66	0	8	74	2	1	0	39	42	116	7.51%	1.49%
					0								
TOTAL	62,277	3,333	316	135	3,784	301	816	5,576	1,589	8,282	12,066	19.38%	1.20%

* White Zone or agricultural area only, does not include "Green Zone"

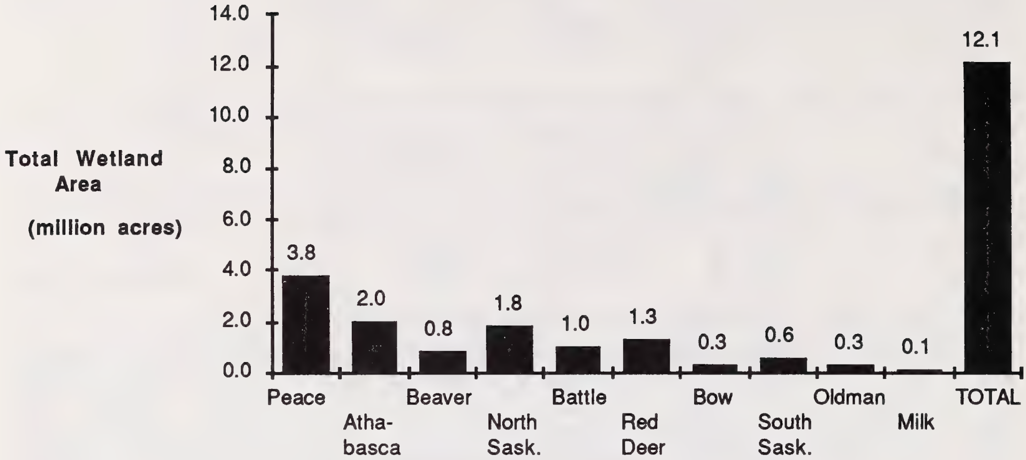


Figure 2.7 TOTAL WETLAND ACREAGE BY RIVER BASIN

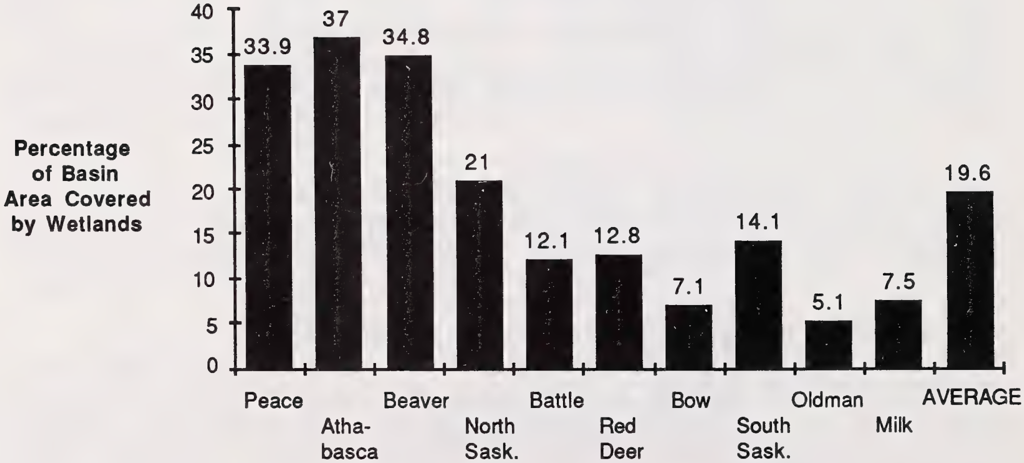


Figure 2.8 WETLAND DENSITY BY RIVER BASIN

use these figures with the understanding that they were generated for this purpose and not for more detailed analyses or comparison. More detail and precision could be obtained if the additional 260 townships which were photographed during this inventory were interpreted.

3. PHASE III: MINI-BASIN STUDIES

3.1 General Introduction

The objective of Phase III was to **identify the practical potential for drainage of wetlands in Alberta, given a number of physical, environmental and economic constraints.** Phase III consisted of studies that assessed these factors for five small watersheds, termed mini-basins, located in central and northern Alberta. The study areas were limited to five because of budget and time constraints and the predominance of wetlands in the northern part of the province. The results of these studies were then combined with the Phase II wetland inventory to determine the drainage potential and constraints for the river basins of central and northern Alberta, as presented in Chapter 4.

3.2 Study Methods

3.2.1 Introduction

Three background studies were commissioned to determine the best method for assessing the drainage potential. The first, on the hydrologic factors affecting drainage (Andres et al. 1984) helped determine the case study or mini-basin approach. A mini-basin is a small, complete watershed about two townships in size. The other two studies examined the wildlife (Green et al. 1984) and economic (Deloitte Haskins & Sells Associates 1984) factors and recommended methods which were modified for use in the mini-basin studies.

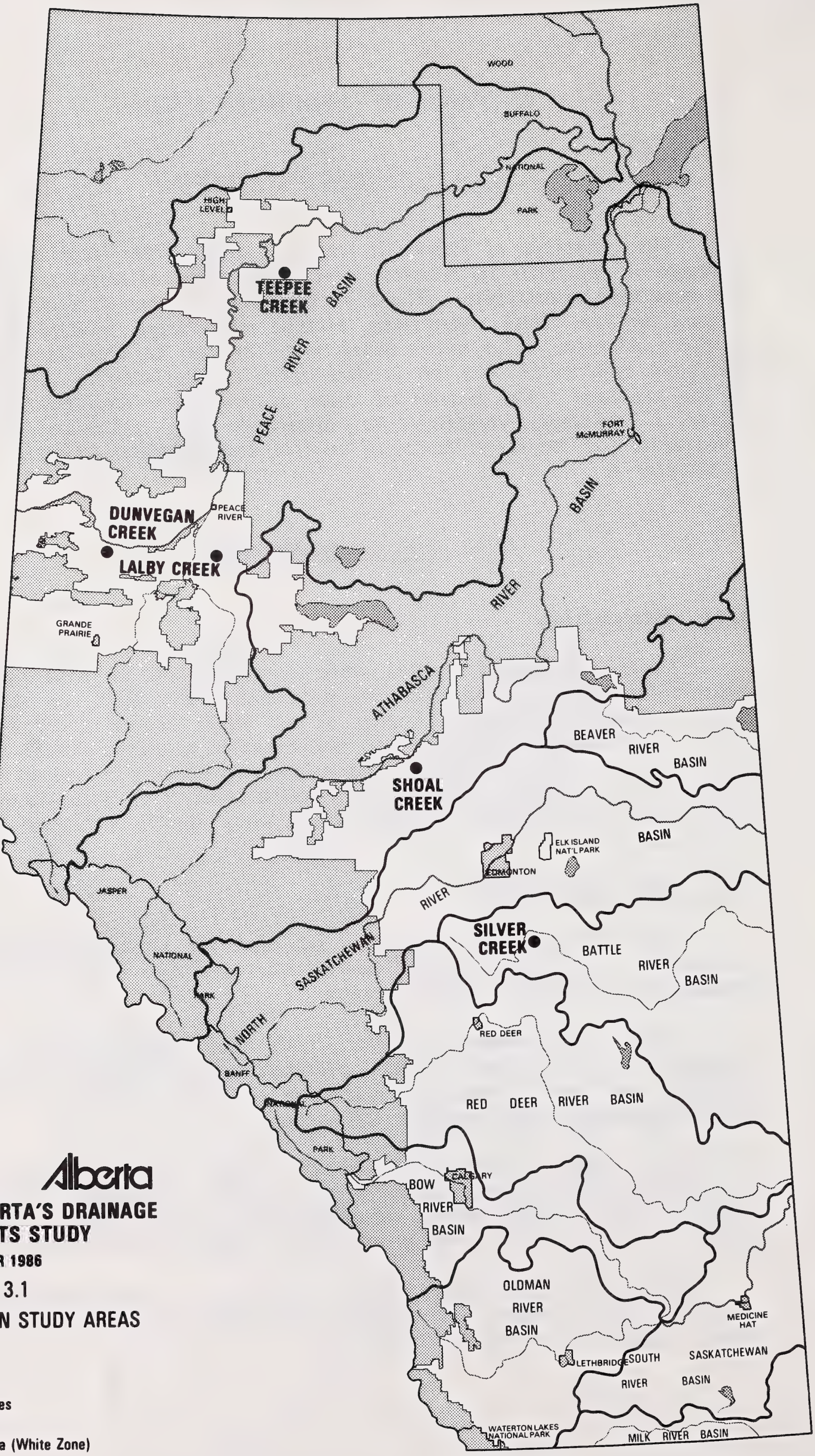
3.2.2 The Study Areas

Each of the five mini-basins selected for study represents a unique combination of agricultural conditions, drainage and related water management problems, and topography.

The first mini-basin is Silver Creek near Camrose (Figure 3.1). This mini-basin is in the Battle River watershed and is within an area typical of the knob and kettle moraine topography of central Alberta. It has some existing drainage works and channelization.

The upper portion of Shoal Creek, near Barrhead in the Pembina/Athabasca River basin, is the second mini-basin. This area has drainage improvements and an increasing demand for drainage. The area has mixed topography and a large proportion of organic soils (bogs and fens).

The third mini-basin, Lalby Creek, is in the Smoky/Peace River watershed near Falher. The land is relatively flat and sheetwater is the major agricultural drainage problem.



Alberta

INVENTORY OF ALBERTA'S DRAINAGE REQUIREMENTS STUDY

SEPTEMBER 1986

FIGURE 3.1

PHASE III MINI-BASIN STUDY AREAS

● Mini-basin

River basin boundaries

Agricultural land area (White Zone)

PRODUCED BY THE RESOURCE EVALUATION AND PLANNING DIVISION, ALBERTA FORESTRY, LANDS AND WILDLIFE, 1986.

Dunvegan Creek in the southern Peace River basin near Spirit River is the fourth mini-basin. It has erosion problems characteristic of this part of the Peace River basin and has a variety of wetland types.

The fifth mini-basin, Tee Pee Creek, is in the northern Peace River watershed in the La Crete area. It is typical of this newly developing area with flat land, indeterminate channels and large areas of undeveloped bush.

No mini-basin from the southern portion of the province was studied. However, it is recognized that some areas of southern Alberta, particularly the Irrigation Districts, have unique drainage and salinity problems which require further investigation.

3.2.3 Interdisciplinary Studies

Each mini-basin was studied to determine the feasibility and implications of wetland drainage. The following disciplines were involved: drainage engineering, hydrology and hydraulics, agronomy, wildlife and fisheries biology, and economics. The study process is shown schematically in Figure 3.2.

Baseline conditions were examined and changes resulting from drainage were predicted. This work was based on information from reports, government files, aerial photograph interpretation and interviews with farmers and others familiar with conditions in the study areas. Time and financial constraints precluded extensive field work.

The mini-basins were studied one by one. As the studies progressed, the methods were refined. If significant changes were made, mini-basins previously studied were re-examined.

3.2.4 Drainage Scenarios

Three drainage scenarios were examined in each mini-basin:

1. TOTAL DRAINAGE: drain all wetlands. This option included both permanent and non-permanent waterbodies, except watercourses, named lakes and dugouts. This option was selected because it relates to the total physical potential for drainage.

2. PARTIAL DRAINAGE: drain non-permanent wetlands only. This option was selected since non-permanent wetlands are less expensive to drain and therefore more likely to be drained.

3. CONSOLIDATION: drain the non-permanent wetlands of each section into one permanent, on-farm ponding area. This option was included because it reduces the need for extensive, off-farm drainage works. It may provide other benefits such as water supply for on-farm uses, downstream flow augmentation or stabilization and water quality control, wildlife mitigation opportunities and potential fish production. On-farm consolidation in this study involved the deepening and diking of a permanent wetland on each section of land to provide sufficient storage. Where applicable, it also included a low-lift electric pump to

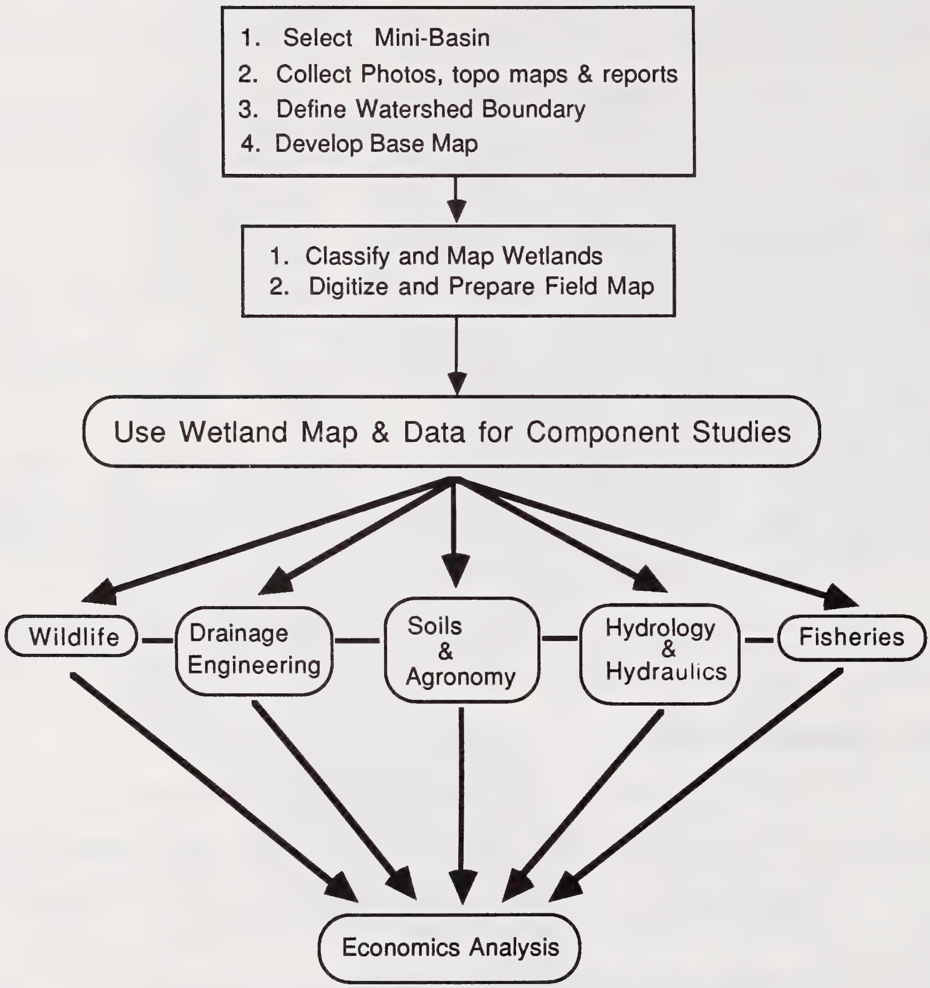


Figure 3.2. PROCESS FOR MINI-BASIN DRAINAGE EVALUATION

move water into the pond and an outlet, such as a slow release pipe, to draw the water level down in preparation for the next runoff event.

3.3 Study Components

3.3.1 Mini-Basin Wetland Inventory

To produce a wetland inventory of each mini-basin the following tasks were completed (see Figure 3.2):

1. Background information was collected from the existing engineering and drainage reports of Alberta Environment and Alberta Agriculture.

2. A 1:20,000 base map showing the watershed boundary, road culverts and drainage ditches was prepared based on field inspection, review of the 1:50,000 topographic maps, and examination of recent panchromatic aerial photographs.

3. Wetlands were delineated and classified using the same classification system developed for the Phase II inventory (Table 2.3). Black and white photographs taken between 1979 and 1983 were used to classify the wetlands of each mini-basin (see Appendix D). Two scales of photography were used, usually 1:60,000 and 1:15,000. The first scale was the primary data source for the wetlands classification. The 1:15,000 scale photographs were used to verify the interpretation of the smaller scale photographs. Field checks were conducted to assess the accuracies of the Phase III mapping and adjustments were made accordingly.

4. Wetland maps were digitized using the same customized computer mapping system (Jensen 1986) as Phase II. A colour map of each mini-basin was produced and wetland data tabulated.

3.3.2 Drainage Engineering

The purpose of the drainage engineering studies was to determine the on-farm costs to drain the wetlands of an average section of land within each mini-basin (an average section is one with the same proportion of all wetland types as the entire basin). These studies examined the farm drainage requirements, alternative drainage methods and designs, and costs. A detailed description of the methods employed appears in the drainage engineering component report by Jensen and Wright (1987).

In each mini-basin three or four actual farm drainage projects were also selected for drainage engineering analysis. The on-farm drainage systems were designed to accommodate runoff from a 1:10 year 24-hour summer storm and to facilitate drainage of excess water from fields within four days of the storm. A period of four days was selected because this is approximately the maximum time a crop can survive flooding. Surface

ditches and sub-surface tile drains were the two alternatives considered. Drainage costs for the farm examples were used to estimate the construction, operation and maintenance costs for an average section.

One farm example in each mini-basin was evaluated for consolidation of drainage water as an alternative to off-farm drainage. Surface and sub-surface movement of water from drained areas, as well as the storage volumes required, were considered. Alternative uses for the water were also reviewed in some of the mini-basins.

3.3.3 Hydrology and Hydraulics

The purpose of the hydrology/hydraulics component was to determine the types of off-farm drainage works and costs required for total and partial drainage. There were two steps in this process: modelling the hydrology of each mini-basin to predict changes in channel flows caused by drainage, and using the results from the model, designing and costing off-farm drainage systems to accommodate the drained water and normal runoff once it leaves the farm. Details of the methods used appear in the hydrology and hydraulics component report by W-E-R Engineering Ltd. (1987).

For each mini-basin, data on several mini-basin characteristics, such as location, size, wetland status, precipitation, surficial geology, existing drainage networks, depressional (wetland) storage and direct runoff were assembled for use in a computer model which predicts flows resulting from total and partial drainage. This was a modified version of the OTTHYMO model which estimates the potential of a drainage area to contribute runoff and predicts peak flows for a simulated 1:10 year 24-hour summer storm. Since little or no streamflow data existed for these mini-basins, the model was calibrated using available data for watercourses in the area. Alberta Environment (Technical Services Division) reviewed these calibrations to ensure they were in the appropriate ranges for Alberta. A detailed report of the modifications and use of the model in this study appear in a separate report by W-E-R Engineering Ltd. (1986).

Analyses were done for uncontrolled and controlled flow of drainage water, as defined below:

1. UNCONTROLLED FLOW. Under this approach there would be no restrictions on the release of flows from the farm, potentially resulting in significant increases in downstream flow peaks.

2. CONTROLLED FLOW. To reduce the potentially large downstream flow peaks, controlled release of flows from drained areas using culverts or other flow restrictions would be used. However, all surface water would be drained within four days of a summer rainfall event.

The controlled flow option was considered because of potential negative impacts, such as high flows, flooding, erosion, scouring and sedimentation, of uncontrolled flows on the receiving stream; and the high cost of engineering works required to mitigate these impacts.

Based on the results of the modelling and other information on the system, hydraulic designs, such as channel and culvert size and drop structures, were prepared for the off-farm drainage works that would be required to accommodate the increased flows from drainage and mitigate downstream impacts. All designs assumed 100 percent participation of the farmers in the basin and a project life of 30 years.

Cost estimates in 1985 dollars, were then calculated for the construction of each design. Annual maintenance costs were assessed as a percentage of capital costs. This percentage was increased in basins where it was judged that specific problems might be encountered over the life of the project.

Existing literature and data were reviewed to provide a general assessment of the drainage impacts on groundwater and water quality.

3.3.4 Soils and Agronomy

The purpose of the soils and agronomy component was to develop methods to assess the agricultural costs and benefits of drainage. Information such as regional climatic data, current land use patterns, and upland crop yields and crop mix was included. Potential development procedures, yields on drained wetland areas and various upland benefits from drainage were determined by interviewing farmers.

A conceptual section farm representing the average wetland and land use conditions for the mini-basin was the basic unit for analysis in this component. The increased costs and benefits of drainage also included the development of all arable bushland because wetlands within arable bush would be drained only as the bush was being cleared and developed for agriculture.

The agronomic analyses were based on general land development schedules outlined for each mini-basin. It was assumed that drainage would be completed in the first year, before any land clearing was undertaken. Preparation of the non-permanent wetland areas would take up to two years and involve clearing, breaking of the soil, root and stone removal, and discing. Most crop production would begin in the fourth year. For permanent wetlands, all activities would be delayed for one year following installation of drainage to allow drying of the area.

The major **benefits** of on-farm drainage were considered to be increased productivity and lower production costs (Leskiw 1987 and Anderson 1987).

1. Increased Productivity

   A. Additional Crop Production. Additional crop production on drained wetland areas and arable bush areas was expressed as "net revenue from drained lands". It was assumed that the crop revenues and production costs for reclaimed wetlands and bushland would be the same as the average for the Census Division in which the mini-basin was situated. Farmers who responded to the agronomy questionnaire

indicated that they expected crop productivity to be about the same as adjacent uplands.

B. Improved Crop Quality. Improved crop quality was expected in transitional (a 50-foot wide band around each wetland) and upland areas because drainage causes a reduction in weed growth, lodging and frost risk. In addition, drainage provides greater opportunities for seeding and harvesting. The improvement in the transitional areas, referred to as "transitional grain quality index", was calculated as a 10 percent increase in production. The corresponding "upland grain quality index" ranged from 0.5 percent in Shoal Creek to 2.0 percent in Silver Creek, because of the differences in wetland size and density.

C. Improved Timing of Operations. This factor takes into account the increased number of farm working days, especially in spring, if wetlands are eliminated allowing earlier access to cultivated fields. This also allows a farmer greater flexibility in his operations. For example, he can switch crops to slower ripening but higher yielding varieties, because of earlier warming of the soil profile. Drainage also increases the potential for harvesting the crop in the event of a wet fall. The timing index varied from one mini-basin to another, from a low of 0.5 percent in Shoal Creek to a high of 5 percent in Silver Creek.

2. Lower Production Costs

A. Reduction in Tillage Overlap Area. The reduction of overlap area on the transitional land was expected to result in lower costs for fertilizer, seed and chemical spraying. It was assumed that costs for these areas would be half those required before drainage. Input costs were estimated for each mini-basin using recent Census Division data.

B. Improved Field Pattern and Working Efficiency. It was anticipated that improved field pattern and working efficiency would reduce operating time and farm costs (e.g. fuel, labour). This factor is dependent on the area drained and the location of any remaining wetlands. Estimates were made for each drainage scenario in each mini-basin area, and amounted to a reduction of three and 10 percent in operating time and farm costs. A farm efficiency model developed by Alberta Agriculture provided these estimates.

The major **costs** associated with on-farm drainage were for drainage area development, lost crop production from surface ditches and initial fertilizing and liming.

1. Drainage Area Development Costs. These are the costs of land preparation activities to develop wetlands for agriculture. For all mini-basins, these were estimated using per acre figures for clearing wetlands surrounded or covered by (A) shrubs/trees, (B)

herbaceous ground cover and (C) other vegetation. These rates were also assumed to represent the per acre cost of simultaneously developing arable bushland in each mini-basin.

2. Surface Ditch Farming Costs. These costs relate to the loss of revenue from areas used for surface drains, to the number of acres that would be taken out of production by drainage works. The additional cost of grassing drainage ditches in the second year was also included.

3. Initial Fertilizer and Liming Costs. Additional fertilizer and liming are required to bring bog/fen areas into production. These costs are applied to bog/fen areas.

3.3.5 Wildlife and Fisheries

3.3.5.1 Wildlife. The purpose of the wildlife component was to evaluate the wildlife habitat associated with each mini-basin's wetlands and to assign a cost for replacement of habitat lost through drainage. No assessment was made for wildlife habitat losses from previous wetland drainage programs.

Mitigation was not considered for drainage of bogs/fens because it would be essentially impossible to create new bog/fen. Also, bog/fen areas are extensive and at this time there is an abundance of them in the Green Zone of the province. Sheetwater areas were also not mitigated because it was assumed they are of limited value to wildlife because of their temporary nature. Watercourses were included in the analysis only if on-stream storage or extensive channel works, which would reduce existing habitat value, were proposed.

The mitigation approach in this study is consistent with Fish and Wildlife Division's policy to maintain wildlife populations by retaining the same amount of habitat in a region affected by drainage. This does not put an actual value on the wildlife per se, but on the cost of replacing habitat which has the capability to support wildlife. No evaluation was made of the possibility of using incentives to induce landowners to preserve wetland habitat. Other methods of assigning economic value to wetland wildlife habitat, such as willingness to pay for hunting and trapping, underestimate its value (Asafu-Adjaye et al. 1986).

The wildlife habitat value of the wetlands of each mini-basin was assessed using a computer model which took into account the area and wildlife suitability rating of each wetland for each of 10 wildlife groups. These groups were: diving waterfowl, dabbling waterfowl, marsh shorebirds, bog/fen shorebirds, songbirds, upland game birds, ungulates, open water furbearers, marshland furbearers and ground-dwelling wildlife. This assessment provided the basis for estimating the effects of drainage on these wildlife groups and the costs to mitigate habitat lost under each drainage scenario. It did not take into account regional difference in species density and diversity. Because land requirements for mitigation were based on the average for all ten wildlife groups, they underestimated the habitat requirements of species for which the wetland habitat is especially important. A detailed description of the methods used for the wildlife component appears in Green et al. (1986).

It was assumed that mitigation for total and partial drainage would be implemented within the region but not in the mini-basin and involve enhancement of existing permanent sloughs or ponds, or creation of new wetland areas. Enhancements could include special landscaping, planting and seeding of the perimeter, establishing upland meadows, constructing nesting islands and building fences, in addition to increasing the actual land area. In some cases this amount of work would not be required and actual costs would be much less.

The mitigation cost estimate for each drainage scenario was based on the average cost of a number of Ducks Unlimited enhancement projects for small wetlands (<30 acres) in central Alberta, plus the average cost of agricultural land in the respective mini-basin. The latter cost was included in the mitigation estimate because land tenure is important for maintaining developed habitat. In practice it may be more feasible to lease the required private lands.

To determine mitigation costs for total and partial drainage, this per acre cost was applied to the estimated land area required for mitigation. Mitigation costs for the consolidation option were determined by using the same per acre enhancement costs plus the cost of any land required over and above the land required for the drainage consolidation pond. If consolidation ponds were constructed on marginal rather than prime productive land, crop production losses and wildlife mitigation costs would be minimized. Costs could be greatly reduced if mitigation was implemented on Crown lands.

3.3.5.2 Fisheries. The purpose of the fisheries studies was to predict the impacts of drainage on the fish within each mini-basin, on the streams connecting the mini-basin wetlands with the major receiving watercourse and on the receiving watercourse itself.

The information generated from airphoto interpretation was determined to be insufficient for a fisheries evaluation of drainage projects (Fernet 1987). The following evaluation was used:

(1) an examination of Canada Land Inventory sport-fish capability maps which indicate the potential of designated areas to support a sport fishery;

(2) a review of existing information on the basin and the receiving watercourses;

(3) interviews with personnel knowledgeable about the mini-basin;

(4) a subjective evaluation of existing and potential fisheries in the wetlands and the receiving stream(s);

(5) predictions regarding effects on this fishery should the wetlands in the watershed be drained;

(6) identification of mitigative options to ameliorate potential negative impacts; and

(7) a judgment regarding extrapolation of these findings to other small watersheds in the same geographic region of the province.

3.3.6 Economics

The purpose of the economics component of this study was to provide an integrated assessment of the feasibility of drainage alternatives in Alberta. Separate analyses were conducted to determine drainage feasibility from two different perspectives. First, a farm financial analysis was undertaken to show the profitability of drainage to the farmer.

Second, a public direct benefit and cost analysis was conducted to show, from a societal point of view, whether the direct agricultural benefits from drainage exceed the direct costs (including farm production costs, public and private investment costs and lost wildlife values).

The results of these analyses are distinct and should not be added to, or subtracted from one another. The main features of each analysis were as follows:

1. Farm Financial Analysis

   A. assumed farmer pays all on-farm aspects of drainage and consolidation pond construction but does not have to pay a portion of costs of off-farm drainage works;
   B. took into account all applicable land development subsidies, taxes and interest payments at 13 percent; and
   C. assumed a 30 year project period.

2. Public Direct Benefits and Costs Analysis

   A. excluded subsidies, taxes and interest payments;
   B. included all on- and off-farm costs such as public drainage system investments and either wildlife habitat mitigation costs or losses in hunting and trapping benefits;
   C. at the mini-basin level all drainage was assumed to be implemented in one year; and
   D. when the results were extrapolated to the major river basin level, it was assumed that drainage development would be phased in over 100 years.

In both analyses a real 5 percent discount rate, 10 year (1973-82) average agricultural prices and 1982 costs and subsidies were used. A real discount rate is the difference between the interest rate charged to borrowers and the rate of inflation. It was assumed that all additional agricultural output would have a market. The analyses evaluated only the incremental changes resulting from drainage, not the viability of existing farming operations or the feasibility of existing agricultural production. All results are given as returns to land, labour, management and existing investment, i.e. these components were not included as costs. In the remainder of this report the results of the farm financial and public direct benefits and costs are shown separately.

More detailed descriptions of these methods can be found in reports by Anderson (1987), MacDonald-Date et al. (1986) and Alberta Agriculture (1986).

3.4 Results of Mini-Basin Studies

Sections 3.2 and 3.3 reviewed the purpose and approach to drainage feasibility assessment at the mini-basin level, Sections 3.4 and 3.5 present the results of this assessment. Chapter 4 extrapolates these results to a river basin level and indicates the necessary modification of gross wetland acreages in terms of drainage potential at a river basin level.

3.4.1 Silver Creek

The studies of the Silver Creek mini-basin examined three drainage scenarios:

1. TOTAL DRAINAGE: drain all wetlands except watercourses.
2. PARTIAL DRAINAGE: drain non-permanent wetlands.
3. CONSOLIDATION: drain and consolidate non-permanent wetlands.

The Silver Creek mini-basin represents areas with numerous small sloughs interspersed with productive farmland. Many farmers in such areas drain these sloughs because they form obstacles to efficient operation of equipment and also affect timing of operations and crop quality on adjacent uplands.

Plate 1 is a map of the Silver Creek mini-basin showing the wetland areas. About 16 percent of the basin is covered with wetlands, mostly classified as non-permanent slough/marsh (Figure 3.3). The uplands are intensively farmed, with 78 percent of the total basin under cultivation (Table 3.1).

Further details pertaining to the Silver Creek mini-basin appear in Appendix D and in the component reports by Anderson (1987), Fernet (1987), Green and Salter (1987), Jensen and Wright (1987), Leskiw (1987) and W-E-R Engineering Ltd. (1987).

3.4.1.1 Farm Financial Results. From a farmer's perspective, both total and partial drainage are financially attractive in the Silver Creek mini-basin (Table 3.2). The positive financial returns for the total and partial drainage scenarios help to explain the public demand for drainage in this part of Alberta. Approximately two thirds of the benefits arise from increased crop production, while the remaining one third is made up of gains in farming efficiency and crop production on adjacent upland areas.

On-farm drainage costs are approximately equal on a per acre basis for the total and partial drainage scenarios, but significantly more for the consolidation scenario. If the public paid for consolidation pond construction, consolidation would be a financially attractive drainage option for the farmer. This alternative would also be more attractive where on-farm water use, such as domestic purposes, stock watering and irrigation were possible.

3.4.1.2 Implications for Wildlife and Fisheries. The wetlands of the Silver Creek basin provide habitat for many species but are especially important to waterfowl, ground dwelling small animals, songbirds, marsh shorebirds and upland gamebirds, in that order. Total drainage would result in the loss of almost all wildlife habitat, whereas losses from partial drainage or consolidation would average 64 or 57 percent respectively. Mitigation to replace the lost habitat would be costly for total or partial drainage; and make total drainage costs greater than benefits (Table 3.3). For the consolidation scenario mitigation costs are much lower, only a fifth of those for partial drainage, because the consolidation pond provides an opportunity for habitat improvements.

The waters of the Silver Creek mini-basin do not provide fisheries habitat but the Battle River is important from a regional recreation viewpoint. Alterations to the flow regime of one tributary, such as Silver Creek, will not likely have an impact on the Battle River but drainage in many tributaries could have a significant impact.

3.4.1.3 Public Direct Benefits and Costs. Assuming that wildlife mitigation is implemented, none of the three drainage scenarios are economically feasible in Silver Creek from a public perspective. All show a negative net present value to society (Table 3.3). For the total and partial drainage scenarios the cost of fully mitigating wildlife habitat losses is considerably higher than the cost of the drainage itself. This is due both to the highly productive value of habitat in this area and to the high costs of replacing such habitat. Of the three scenarios, consolidation is the most attractive when wildlife mitigation is included.

If mitigation is not assumed, the total and partial drainage scenarios are economically viable and the consolidation option remains negative.

Table 3.1
SILVER CREEK MINI-BASIN WETLAND TYPES AND UPLAND USE

WETLANDS	AREA (acres)	% of Mini-Basin Area	Number of Wetlands	UPLANDS	AREA (acres)	% of Mini-Basin Area
Non-permanent				Cultivated	26,590	77.6%
Slough/Marsh	3,996	11.7%	1351	Farms/Fences	1,070	3.1%
Seep	133	0.4%	5	Bush (arable)	1,123	3.3%
Permanent				SUB TOTAL	28,783	84.0%
Slough/Marsh	664	1.9%	178			
Lake/Pond	556	1.6%	116			
Watercourse	135	0.4%	23	**MINI-BASIN AREA**	**34,267**	
SUB-TOTAL	5,484	16.0%	1673	Source: Leskiw (1986), p. 11.		

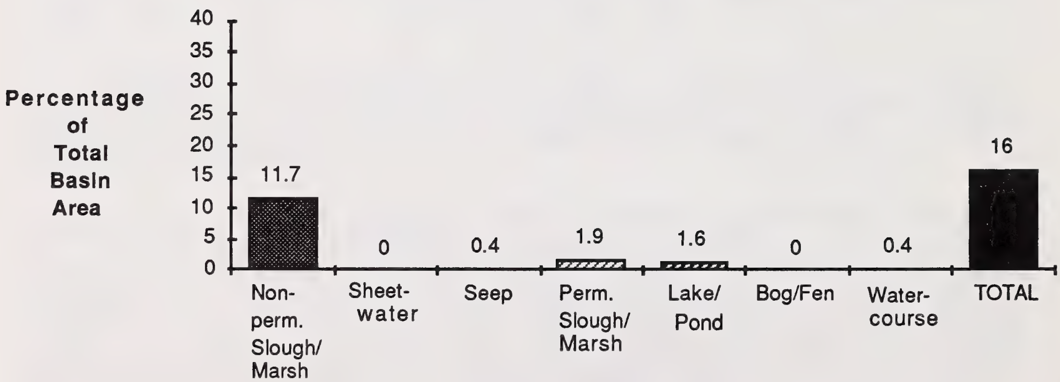
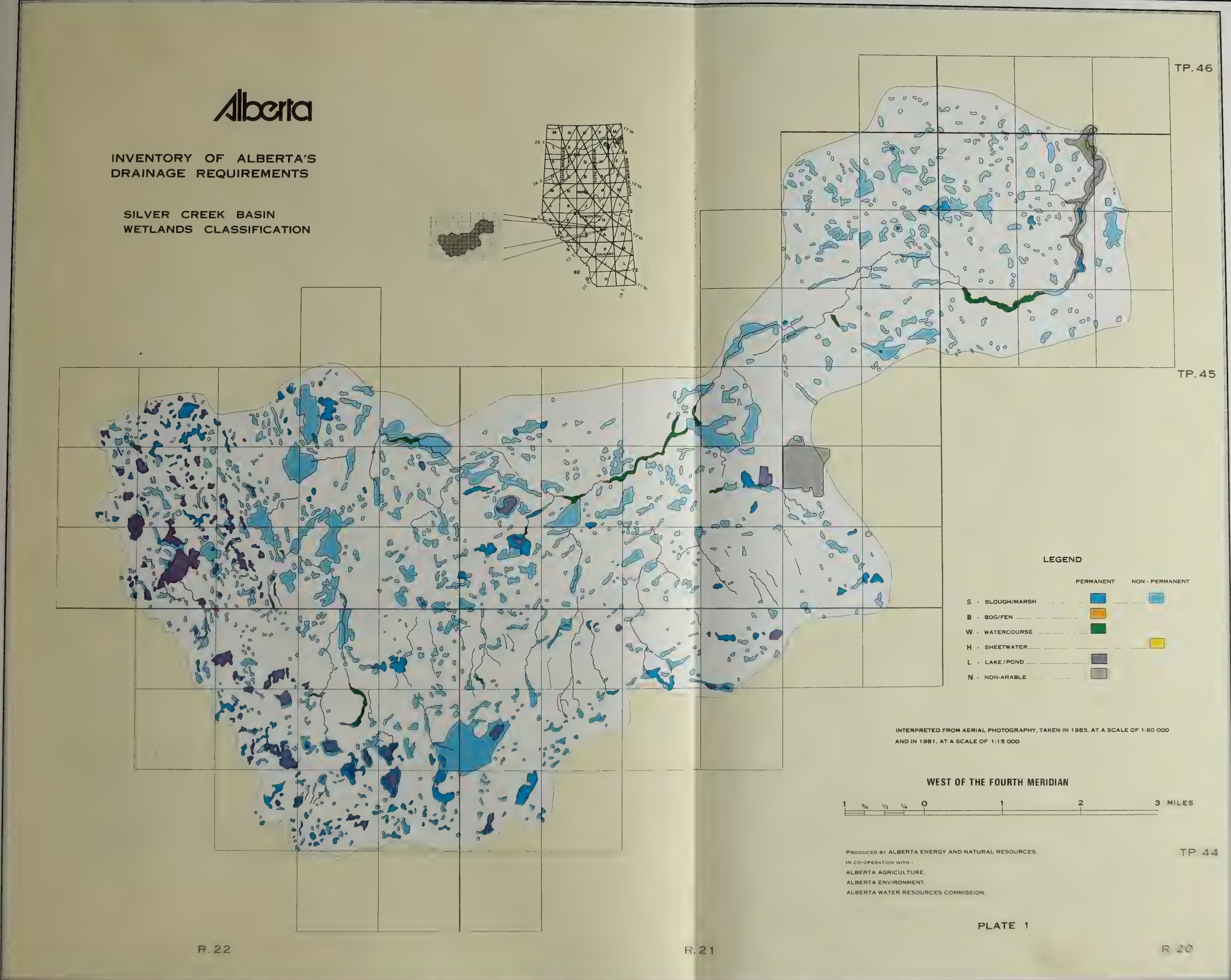


Figure 3.3 SILVER CREEK MINI-BASIN WETLAND DISTRIBUTION



Alberta
INVENTORY OF ALBERTA'S DRAINAGE REQUIREMENTS
SILVER CREEK BASIN WETLANDS CLASSIFICATION
TP. 46
TP. 45
TP. 44
LEGEND
PERMANENT
NON - PERMANENT
S - SLOUGH/MARSH
B - BOG/FEN
W - WATERCOURSE
H - SHEETWATER
L - LAKE / POND
N - NON-ARABLE
INTERPRETED FROM AERIAL PHOTOGRAPHY, TAKEN IN 1983, AT A SCALE OF 1:60 000 AND IN 1981, AT A SCALE OF 1:15 000
WEST OF THE FOURTH MERIDIAN
1 3/4 1/2 1/4 0 1 2 3 MILES
PRODUCED BY ALBERTA ENERGY AND NATURAL RESOURCES.
IN CO-OPERATION WITH -
ALBERTA AGRICULTURE.
ALBERTA ENVIRONMENT.
ALBERTA WATER RESOURCES COMMISSION.
R. 22
R. 21
R. 20

PLATE 1

Table 3.2

SILVER CREEK FARM FINANCIAL ANALYSIS
(present value over 30 years)

DRAINAGE SCENARIO	Acres Drained per Average Section	AVERAGE ANNUAL COSTS*	AVERAGE ANNUAL BENEFITS**	AVERAGE ANNUAL NET RETURN
		- $ per acre drained-		
TOTAL DRAINAGE	100	167	193	26
PARTIAL DRAINAGE	75.5	151	196	45
CONSOLIDATION	75.5	248	216	-32

* includes initial capital costs
** this includes both production revenue and financing to cover the capital cost

Table 3.3

SILVER CREEK PUBLIC DIRECT BENEFITS AND COSTS
(present value over 30 years)

NET PRESENT VALUE***	BENEFITS	INVESTMENT COSTS			TOTAL INVESTMENT COSTS	NPV*** WITH WILDLIFE MITIGATION	NPV*** WITHOUT WILDLIFE MITIGATION
	Gross Margin**	On-Farm Drainage	Off-Farm Drainage	Wildlife Mitigation*			
$/ACRE DRAINED							
Total Drainage	1,380	745	464	3,013	4,222	-2,842	171
Partial Drainage	1,607	630	614	2,534	3,778	-2,171	363
Consolidation	1,380	1,632	0	507	2,139	-759	-252
TOTAL ($ thousands)							
Total Drainage	7,384	3,983	2,482	16,118	22,583	-15,199	919
Partial Drainage	6,493	2,544	2,482	10,237	15,263	-8,770	1,467
Consolidation	5,575	6,593	0	2,047	8,640	-3,065	-1,018

* 100 percent wildlife mitigation
** Gross Margin = gross farm receipts minus production costs
*** Net Present Value (NPV) = Gross Margin minus total investment costs

3.4.2 Shoal Creek

The studies of the Shoal Creek mini-basin examined three drainage scenarios:

1. TOTAL DRAINAGE: drain all wetlands except watercourses and Shoal Lake.
2. PARTIAL DRAINAGE: drain non-permanent slough/marsh.
3. CONSOLIDATION: drain and consolidate non-permanent slough/marsh.

The Shoal Creek mini-basin represents areas which are partially developed for agriculture and which have a significant proportion of the undeveloped land occupied by bogs and fens (organic soils). Most farmers have given drainage priority to sloughs and small peat bogs which hamper efficient field operations. In the future, more drainage will be undertaken as part of the conversion of large tracts of undeveloped land to productive farmland.

Plate 2 is a map of the Shoal Creek mini-basin showing the wetland areas. About 38 percent of the mini-basin is covered with wetlands, most of it bog/fen (see Figure 3.4). Shoal Lake and other lake/ponds cover a total area of approximately 3,200 acres or 5.3 percent of the mini-basin. Slough/marsh covers about 2.1 percent of the mini-basin area, mostly non-permanent. About 55 percent of the mini-basin is cultivated (Table 3.4).

Further details pertaining to the Shoal Creek mini-basin appear in Appendix D and in the component reports by Anderson (1987), Fernet (1987), Green and Salter (1987), Jensen and Wright (1987), Leskiw (1987) and W-E-R Engineering Ltd. (1987).

3.4.2.1 Farm Financial Results. From the farmer's perspective it is financially feasible to totally or partially drain wetlands in the Shoal Creek mini-basin, but not to consolidate (Table 3.5). Partial drainage is the best option. The net average annual return for the total drainage option includes the development of large areas of bog/fen. This figure is an average and will vary considerably depending on the composition, depth and vegetation cover of the peat lands, and as more information on their development and agronomic potential is gained.

The net annual returns for Shoal Creek are the lowest of the five mini-basins, because of the lower per acre agricultural benefits and above average costs.

The per acre costs for the consolidation option are almost twice those for total and partial drainage. Public cost sharing of consolidation pond construction would be required to make this drainage scenario attractive to the farmer. If the pond could play a role in providing on-farm water needs, the consolidation option would also be more acceptable to the farmer.

A large proportion of the agricultural benefits from drainage are attributed to increased crop production on drained wetland areas, particularly for partial drainage where only a small proportion of the basin is drained.

<u>3.4.2.2 Implications for Wildlife and Fisheries.</u> The Shoal Creek mini-basin, which is dominated by bog/fen and slough/marsh wetlands, has large amounts of habitat for waterfowl and bog/fen shorebirds and is also important for open water furbearers, upland game birds and small, ground dwelling animals. Total drainage would remove most of this habitat as well as the associated woodland cover. Partial drainage or consolidation would have only a minor impact on habitat causing reductions of 8 and 5 percent respectively. The mitigation cost on a per acre drained basis for the total drainage scenario (Table 3.6) is very low because large areas of bog/fen would not be mitigated. In contrast, the per acre mitigation costs for partial drainage reflect the high value of the non-permanent slough/marshes of this mini-basin. Fisheries were not a concern in this mini-basin.

<u>3.4.2.3 Public Direct Benefits and Costs.</u> None of the drainage scenarios are economically feasible, even with wildlife mitigation excluded (Table 3.6). This is due, for total drainage, to the relatively low agricultural productivity of bog and fen areas and, for partial drainage, to higher off-farm per acre costs for the drainage of a small area of non-permanent wetlands. On a per acre drained basis, total drainage is the most attractive option but only a small proportion of the wetlands are considered in the mitigation analysis. The consolidation option is more attractive than partial drainage whether wildlife mitigation is included or not, because of the high off-farm costs associated with drainage of few, isolated non-permanent wetlands.

Table 3.4
SHOAL CREEK MINI-BASIN WETLAND TYPES AND UPLAND USE

WETLANDS	AREA (acres)	% of Mini-Basin Area	Number of Wetlands	UPLANDS	AREA (acres)	% of Mini-Basin Area
Non-permanent				Cultivated	33,559	55.3%
Slough/Marsh	972	1.6%	135	Roads	550	0.9%
Permanent				Farmsteads	550	0.9%
Slough/Marsh	293	0.5%	67	Bush (arable)	2,467	4.1%
Bog/Fen	17,856	29.4%	489	Non-arable	640	1.1%
Lake/Pond	805	1.3%	73			
Shoal Lake & bordering				SUB TOTAL	37,766	62.3%
Slough/Marsh	2,444	4.0%	12			
Watercourse	501	0.8%	30	**MINI-BASIN AREA**	**60,637**	
SUB-TOTAL	22,871	37.7%	806	Source: Leskiw (1986), p. 12.		

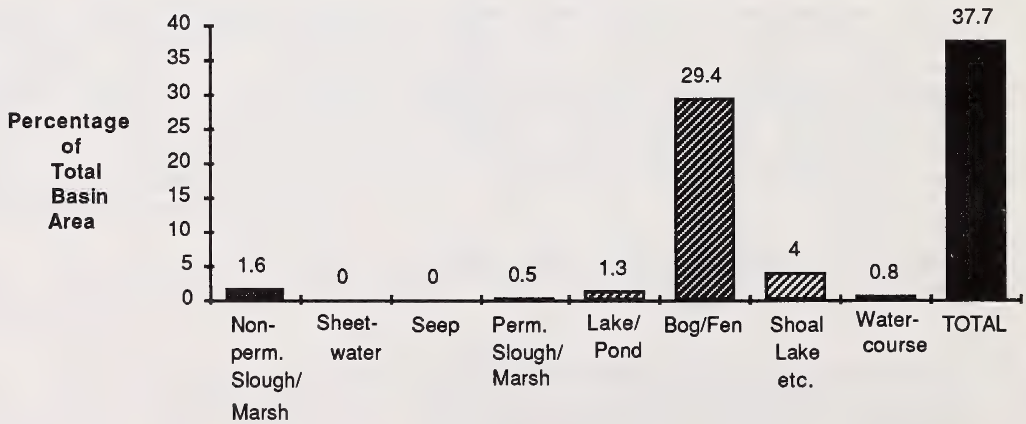


Figure 3.4 SHOAL CREEK MINI-BASIN WETLAND DISTRIBUTION

Alberta
INVENTORY OF ALBERTA'S
DRAINAGE REQUIREMENTS
SHOAL CREEK BASIN
WETLANDS CLASSIFICATION
PRODUCED BY ALBERTA ENERGY AND NATURAL RESOURCES.
IN CO-OPERATION WITH -
ALBERTA AGRICULTURE.
ALBERTA ENVIRONMENT.
ALBERTA WATER RESOURCES COMMISSION.
TP. 61
TP. 60
LEGEND
PERMANENT
NON - PERMANENT
S - SLOUGH/MARSH
B - BOG/FEN
W - WATERCOURSE
H - SHEETWATER
L - LAKE / POND
N - NON-ARABLE
INTERPRETED FROM AERIAL PHOTOGRAPHY, TAKEN IN 1982, AT A SCALE OF 1:60 000
AND IN 1983, AT A SCALE OF 1:15 000
WEST OF THE FIFTH MERIDIAN
1 0 1 2 3 MILES
R. 5
R. 4
R. 3

PLATE 2

Table 3.5

SHOAL CREEK FARM FINANCIAL ANALYSIS
(present value over 30 years)

DRAINAGE SCENARIO	Acres Drained per Average Section	AVERAGE ANNUAL COSTS*	AVERAGE ANNUAL BENEFITS**	AVERAGE ANNUAL NET RETURN
		- $ per acre drained-		
TOTAL DRAINAGE	210.3	105	111	6
PARTIAL DRAINAGE	10.2	124	140	16
CONSOLIDATION	10.2	238	123	-115

* includes initial capital costs

** this includes both production revenue and financing to cover the capital cost

Table 3.6

SHOAL CREEK PUBLIC DIRECT BENEFITS AND COSTS
(present value over 30 years)

NET PRESENT VALUE***	BENEFITS	INVESTMENT COSTS			TOTAL INVESTMENT COSTS	NPV*** WITH WILDLIFE MITIGATION	NPV*** WITHOUT WILDLIFE MITIGATION
	Gross Margin**	On-Farm Drainage	Off-Farm Drainage	Wildlife Mitigation*			
$/ACRE DRAINED							
Total Drainage	415	187	355	228	770	-355	-127
Partial Drainage	1,160	447	1,315	2,030	3,792	-2,632	-602
Consolidation	1,231	1,425	0	626	2,051	-820	-194
TOTAL ($ thousands)							
Total Drainage	8,266	3,722	7,073	5,224	16,019	-7,753	-2,529
Partial Drainage	1,128	434	1,278	2,990	4,702	-3,574	-584
Consolidation	1,197	1,385	0	608	1,993	-796	-188

* 100 percent wildlife mitigation

** Gross Margin = gross farm receipts minus production costs

*** Net Present Value (NPV) = Gross Margin minus total investment costs

3.4.3 Lalby Creek

The studies of the Lalby Creek mini-basin examined three drainage scenarios:

1. TOTAL DRAINAGE: drain non-permanent slough/marsh, sheetwater and bog/fen (permanent slough/marsh and lake/pond were not included, because Lac Magloire represents about 95 percent of these types).
2. PARTIAL DRAINAGE: drain non-permanent slough/marsh and sheetwater.
3. CONSOLIDATION: drain and consolidate non-permanent wetlands (non-permanent slough/marsh and sheetwater).

Lalby Creek is a flat, moderately intensively cultivated mini-basin, with over 60 percent of its area under cultivation (Table 3.7). Plate 3 shows the wetland areas of this mini-basin. Over 28 percent of the mini-basin is occupied by wetlands, over half of which are classified as sheetwater, temporary shallow flooding mostly in cultivated areas (Figure 3.5). Sheetwater causes the most serious agricultural losses in this mini-basin - snowmelt often delays or prevents seeding in the spring, and summer rainfall may cause flooding of growing crops.

Farmers have attempted to remove excess water by individual or group drainage projects which direct runoff to road ditches. This activity, however, has often resulted in flooding of downstream properties. Downstream flooding has also increased with the clearing and drainage of bog/fen wetlands in the upper portion of the basin.

Further details pertaining to the Lalby Creek mini-basin appear in Appendix D and in the component reports by Anderson (1987), Fernet (1987), Green and Salter (1987), Jensen and Wright (1987), Leskiw (1987) and W-E-R Engineering Ltd. (1987).

3.4.3.1 Farm Financial Results. Total and partial drainage in the Lalby Creek mini-basin are financially feasible for the farmer, with partial drainage producing the highest average annual net returns of the five mini-basins (Table 3.8). Consolidation yields a negative average annual net return.

On-farm costs are similar for total and partial drainage on a per acre basis, and almost twice as much for consolidation. The consolidation option would be financially attractive if pond construction were subsidized by the public and/or the farmer could realize on-farm benefits from the use of the water held in the consolidation pond.

3.4.3.2 Implications for Wildlife and Fisheries. This basin provides suitable habitat for a large variety of animals, however almost a third of it is associated with Lac Magloire, which is not considered in any of the drainage scenarios. The remaining habitat is mostly suitable for the small ground dwelling species, bog/fen shorebirds, waterfowl, upland gamebirds and ungulates, in that order. Habitat losses from total drainage would again be extensive (80 percent) but less than 40 percent for either partial drainage or consolidation. Costs for mitigation are lowest in this basin (Table 3.9),

primarily because sheetwater losses were not mitigated (see Section 3.3.5.1). There is no sport fishery in this mini-basin.

3.4.3.3 Public Direct Benefits and Costs. From a public perspective, all drainage scenarios in the Lalby Creek mini-basin are economically viable, with or without wildlife mitigation (Table 3.9). There were no wildlife mitigation costs assigned to sheetwater which makes up most of the mini-basin's wetland area. Partial drainage is the most attractive option and yields the highest returns of all the mini-basins. Both on and off-farm per acre costs are very low compared with the other mini-basins.

Table 3.7
LALBY CREEK MINI-BASIN WETLAND TYPES AND UPLAND USE

WETLANDS	AREA (acres)	% of Mini-Basin Area	Number of Wetlands	UPLANDS	AREA (acres)	% of Mini-Basin Area
Non-permanent				Cultivated	26,578	61.5%
Slough/Marsh	857	2.0%	223	Roads	400	0.9%
Sheetwater	7,738	17.9%	134	Farmsteads	400	0.9%
Permanent				Bush (arable)	3,240	7.5%
Slough/Marsh	485	1.1%	38			
Bog/Fen	1,406	3.3%	78	SUB TOTAL	30,618	70.8%
Lake/Pond	1,678	3.9%	73			
Watercourse	448	1.0%	26	**MINI-BASIN AREA**	**43,230**	
SUB-TOTAL	12,612	29.2%	572	Source: Leskiw (1986), p. 13.		

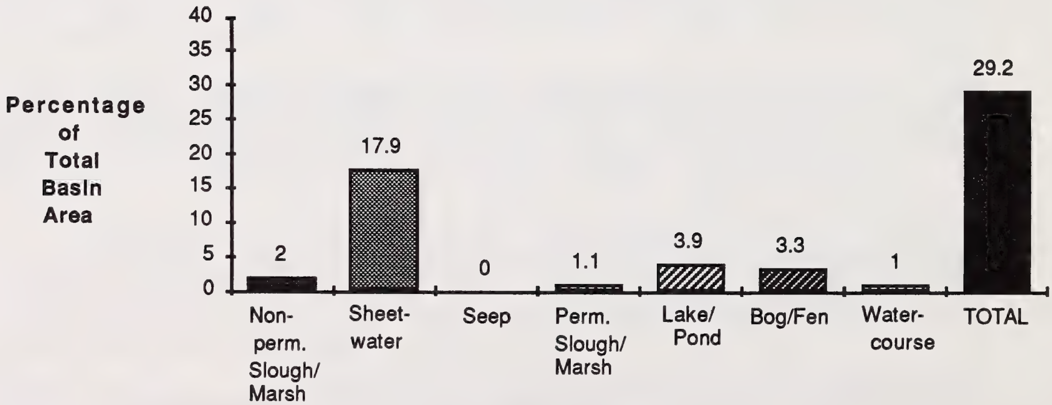
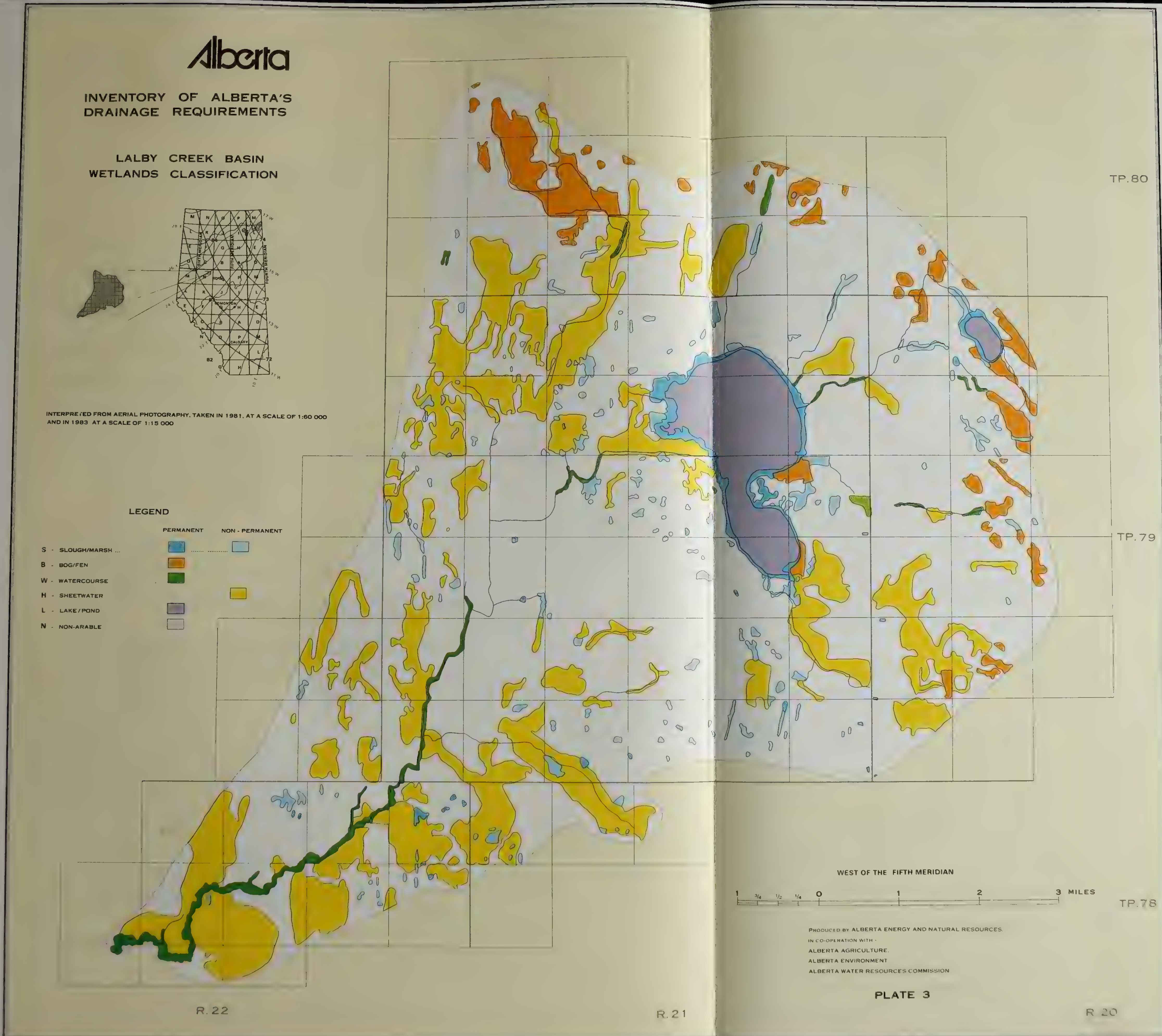


Figure 3.5 LALBY CREEK MINI-BASIN WETLAND DISTRIBUTION



Alberta
INVENTORY OF ALBERTA'S DRAINAGE REQUIREMENTS
LALBY CREEK BASIN
WETLANDS CLASSIFICATION
INTERPRETED FROM AERIAL PHOTOGRAPHY, TAKEN IN 1981, AT A SCALE OF 1:60 000 AND IN 1983 AT A SCALE OF 1:15 000
LEGEND
PERMANENT
NON - PERMANENT
S - SLOUGH/MARSH
B - BOG/FEN
W - WATERCOURSE
H - SHEETWATER
L - LAKE/POND
N - NON-ARABLE
TP. 80
TP. 79
TP. 78
WEST OF THE FIFTH MERIDIAN
1 3/4 1/2 1/4 0 1 2 3 MILES
PRODUCED BY ALBERTA ENERGY AND NATURAL RESOURCES.
IN CO-OPERATION WITH -
ALBERTA AGRICULTURE.
ALBERTA ENVIRONMENT
ALBERTA WATER RESOURCES COMMISSION
R. 22
R. 21
R. 20

PLATE 3

Table 3.8

LALBY CREEK FARM FINANCIAL ANALYSIS
(present value over 30 years)

DRAINAGE SCENARIO	Acres Drained per Average Section	AVERAGE ANNUAL COSTS*	AVERAGE ANNUAL BENEFITS**	AVERAGE ANNUAL NET RETURN
		- $ per acre drained-		
TOTAL DRAINAGE	90.8	91	118	27
PARTIAL DRAINAGE	70	70	124	54
CONSOLIDATION	70	162	156	-6

* includes initial capital costs
** this includes both production revenue and financing to cover the capital cost

Table 3.9

LALBY CREEK PUBLIC DIRECT BENEFITS AND COSTS
(present value over 30 years)

NET PRESENT VALUE***	BENEFITS	INVESTMENT COSTS			TOTAL INVESTMENT COSTS	NPV*** WITH WILDLIFE MITIGATION	NPV*** WITHOUT WILDLIFE MITIGATION
	Gross Margin**	On-Farm Drainage	Off-Farm Drainage	Wildlife Mitigation*			
$/ACRE DRAINED							
Total Drainage	558	176	249	68	493	65	133
Partial Drainage	596	88	290	79	457	139	218
Consolidation	569	479	0	42	521	48	90
TOTAL ($ thousands)							
Total Drainage	5,578	1,762	2,493	682	4,937	641	1,323
Partial Drainage	5,124	757	2,493	682	3,932	1,192	1,874
Consolidation	4,891	4,113	0	360	4,473	418	778

* 100 percent wildlife mitigation
** Gross Margin = gross farm receipts minus production costs
*** Net Present Value (NPV) = Gross Margin minus total investment costs

3.4.4. Dunvegan Creek

The studies of the Dunvegan Creek mini-basin examined three drainage scenarios:

1. TOTAL DRAINAGE: drain all wetlands except watercourses.
2. PARTIAL DRAINAGE: drain all non-permanent wetlands.
3. CONSOLIDATION: drain and consolidate non-permanent wetlands.

The Dunvegan Creek mini-basin in northwestern Alberta represents developed agricultural areas which have high soil erosion potential. Most of the wetlands in this area are small non-permanent slough/marshes which farmers are interested in draining to improve field efficiency. Sheetwater is a minor wetland problem.

Plate 4 is a map of the Dunvegan Creek mini-basin showing the wetland areas. Only about 12 percent of the basin is occupied by wetlands, most of it non-permanent, over 7 percent of the basin area is non-permanent slough/marsh and about 2 percent is sheetwater (Figure 3.6). Bog/fen was not identified in this mini-basin. Almost 70 percent of the basin is cultivated, and another 11 percent is steep, hence non-arable (Table 3.10).

Further details pertaining to the Dunvegan Creek mini-basin appear in Appendix D and in the component reports by Anderson (1987), Fernet (1987), Green and Salter (1987), Jensen and Wright (1987), Leskiw (1987) and W-E-R Engineering Ltd. (1987).

3.4.4.1 Farm Financial Results. In the Dunvegan Creek mini-basin total and partial drainage are equally financially viable for the farmer (Table 3.11. If the cost of consolidation pond construction was covered by the public or justified by on-farm water use benefits, consolidation might be acceptable to the farmer. Over 80 percent of the agricultural benefits from drainage in this mini-basin are from cultivation of drained wetland areas.

3.4.4.2 Implications for Wildlife and Fisheries. Habitat, especially for waterfowl, bog/fen shorebirds, ungulates, upland gamebirds and small animals is available in this mini-basin. Much of it (two-thirds) is associated directly with the creek channel but only a portion of this will be lost during drainage because of erosion control and flood protection measures. Relative habitat losses for the total drainage scenario (51%) are therefore not as severe in this basin as in some of the others. Partial drainage and consolidation result in reductions of 43 percent and 22 percent respectively. Mitigation is relatively expensive for both the total and partial drainage scenarios (Table 3.12) but is much less for the consolidation option. Dunvegan Creek does not have a sport fishery.

3.4.4.3 Direct Public Benefits and Costs. From the public perspective, all three drainage scenarios are uneconomic in the Dunvegan Creek mini-basin, whether wildlife mitigation is considered or not (Table 3.12). Consolidation is the most attractive option because it eliminates the need for expensive off-farm erosion control measures. Wildlife mitigation costs are considerably less for consolidation than for partial drainage. Per acre agricultural benefits are high but off-farm costs are significantly higher than for other mini-basins, and wildlife mitigation costs are also high.

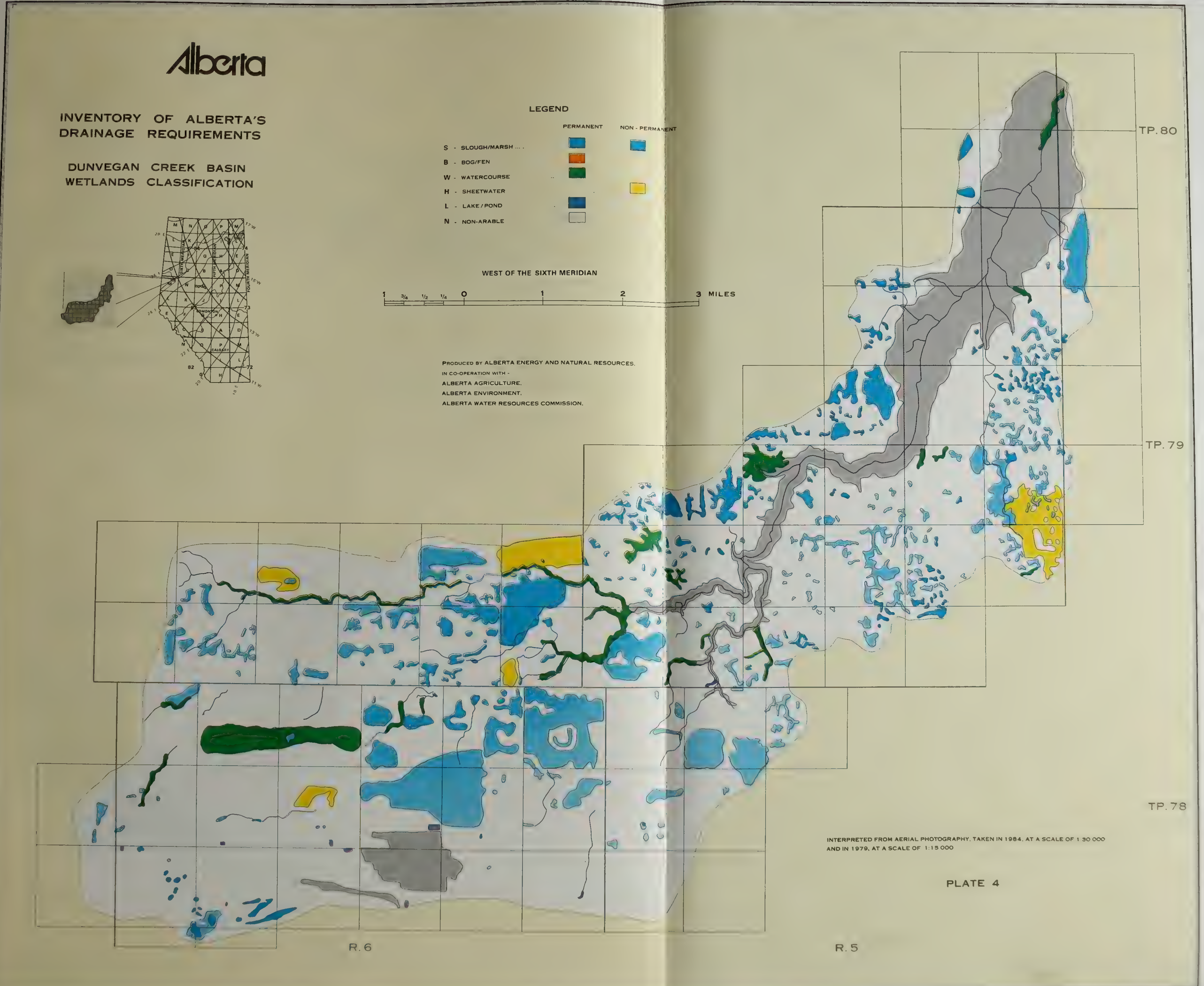
See next page for Dunvegan Creek Mini-Basin figure and tables

Table 3.10
DUNVEGAN CREEK MINI-BASIN WETLAND TYPES AND UPLAND USE

WETLANDS	AREA (acres)	% of Mini-Basin Area	Number of Wetlands	UPLANDS	AREA (acres)	% of Mini-Basin Area
Non-permanent				Cultivated	24,573	68.9%
Slough/Marsh	2,636	7.4%	358	Roads	335	0.9%
Sheetwater	574	1.6%	9	Farmsteads	335	0.9%
Seep	33	0.1%	2	Bush (arable)	2,370	6.6%
Permanent				Non-arable	3,966	11.1%
Slough/Marsh	315	0.9%	124			
Lake/Pond	22	0.1%	54	SUB TOTAL	31,579	88.5%
Watercourse	521	1.5%	36	**MINI-BASIN AREA**	**35,680**	
SUB-TOTAL	4,101	11.5%	583			

Source: Leskiw (1986), p. 14.

Figure 3.6 DUNVEGAN CREEK MINI-BASIN WETLAND DISTRIBUTION



Alberta
INVENTORY OF ALBERTA'S DRAINAGE REQUIREMENTS
DUNVEGAN CREEK BASIN WETLANDS CLASSIFICATION
LEGEND
PERMANENT
NON - PERMANENT
S - SLOUGH/MARSH
B - BOG/FEN
W - WATERCOURSE
H - SHEETWATER
L - LAKE / POND
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WEST OF THE SIXTH MERIDIAN
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ALBERTA ENVIRONMENT.
ALBERTA WATER RESOURCES COMMISSION.
TP. 80
TP. 79
TP. 78
R. 6
R. 5
INTERPRETED FROM AERIAL PHOTOGRAPHY, TAKEN IN 1984, AT A SCALE OF 1 30 000 AND IN 1979, AT A SCALE OF 1:15 000
PLATE 4

Table 3.11

DUNVEGAN CREEK FARM FINANCIAL ANALYSIS
(present value over 30 years)

DRAINAGE SCENARIO	Acres Drained per Average Section	AVERAGE ANNUAL COSTS*	AVERAGE ANNUAL BENEFITS**	AVERAGE ANNUAL NET RETURN
		- $ per acre drained-		
TOTAL DRAINAGE	64.5	99	140	41
PARTIAL DRAINAGE	57.8	101	142	41
CONSOLIDATION	57.8	201	177	-24

* includes initial capital costs
** this includes both production revenue and financing to cover the capital cost

Table 3.12

DUNVEGAN CREEK PUBLIC DIRECT BENEFITS AND COSTS
(present value over 30 years)

NET PRESENT VALUE***	BENEFITS	INVESTMENT COSTS			TOTAL INVESTMENT COSTS	NPV*** WITH WILDLIFE MITIGATION	NPV*** WITHOUT WILDLIFE MITIGATION
	Gross Margin**	On-Farm Drainage	Off-Farm Drainage	Wildlife Mitigation*			
$/ACRE DRAINED							
Total Drainage	1,190	402	2,357	2,046	4,805	-3,615	-1,569
Partial Drainage	1,153	336	2,628	1,869	4,833	-3,680	-1,811
Consolidation	1,018	1,303	0	309	1,612	-594	-285
TOTAL ($ thousands)							
Total Drainage	4,261	1,439	8,437	8,326	18,202	-13,941	-5,615
Partial Drainage	3,701	1,080	8,437	6,973	16,490	-12,789	-5,816
Consolidation	3,268	4,183	0	993	5,176	-1,908	-915

* 100 percent wildlife mitigation
** Gross Margin = gross farm receipts minus production costs
*** Net Present Value (NPV) = Gross Margin minus total investment costs

3.4.5 Tee Pee Creek

The studies of the Tee Pee Creek mini-basin examined three drainage scenarios:

1. TOTAL DRAINAGE: drain all wetlands.
2. PARTIAL DRAINAGE: drain non-permanent wetlands (non-permanent slough/marsh and sheetwater).
3. CONSOLIDATION: drain and consolidate non-permanent wetlands.

The Tee Pee Creek mini-basin lies in a developing agricultural area of northern Alberta, with a relatively high concentration of wetlands. The greatest incentives to drain in this area are to eliminate sheetwater flooding and to expand the agricultural land base into areas dominated by bog/fen. Less than 50 percent of the mini-basin area is currently cultivated (Table 3.13).

Plate 5 is a map of the Tee Pee Creek mini-basin showing the wetland areas. Almost 28 percent of the mini-basin is occupied by wetlands, and over half of this is affected by bog/fen (Figure 3.7). Sheetwater accounts for almost 7 percent of the basin area, and non-permanent slough/marsh almost 1 percent. The sheetwater areas in this basin are believed to be primarily backflooding areas resulting from channel blockages.

Further details pertaining to the Tee Pee Creek mini-basin appear in Appendix D and in the component reports by Anderson (1987), Fernet (1987), Green and Salter (1987), Jensen and Wright (1987), Leskiw (1987) and W-E-R Engineering Ltd. (1987).

3.4.5.1 Farm Financial Results. From the farmer's perspective all drainage options are financially viable in the Tee Pee Creek mini-basin, with partial drainage being the most attractive and consolidation yielding a much smaller average annual net return (Table 3.14). Over 80 percent of the agricultural benefits from drainage are from increased crop production on drained wetland areas and the rest is attributed to gains in farming efficiency and crop production in adjacent upland areas.

On-farm costs are similar for the total and partial drainage options but over twice as much for consolidation. If the consolidation pond could be justified in terms of benefits from on-farm water use, this option might be more attractive at the farm level.

3.4.5.2 Implications for Wildlife and Fisheries. Tee Pee Creek mini-basin, a relatively undeveloped area, provides habitat for many species, especially waterfowl, bog/fen shorebirds, upland gamebirds, ground dwelling small animals and ungulates. Most of this is extensive, tree covered bog/fen areas. Essentially all the wetland habitat in the mini-basin would be lost if total drainage were implemented. Partial drainage or consolidation would result in much lower losses (17 and 6 percent) because none of the bog/fen would be drained. Mitigation costs are presented in Table 3.15. They are considerably lower, both in total and on a per acre drained basis, for consolidation than for the other drainage options. Fisheries are not a concern in this mini-basin since there are obstacles to upstream fish passage from the Bear River.

3.4.5.3 Public Direct Benefits and Costs. Assuming wildlife mitigation, except for bog/fen and sheetwater, all three drainage scenarios are uneconomic (Table 3.15). Consolidation is the best option if wildlife mitigation is included. Partial drainage is the only economic option, if wildlife mitigation is excluded.

Table 3.13
TEE PEE CREEK MINI-BASIN WETLAND TYPES AND UPLAND USE

WETLANDS	AREA (acres)	% of Mini-Basin Area	Number of Wetlands	UPLANDS	AREA (acres)	% of Mini-Basin Area
Non-permanent				Cultivated	19,290	47.8%
Slough/Marsh	393	1.0%	23	Roads	360	0.9%
Sheetwater	2,659	6.6%	47	Farmsteads	360	0.9%
Permanent				Bush (arable)	7,026	17.4%
Slough/Marsh	240	0.6%	11	Non-arable	2,040	5.1%
Bog/Fen	6,943	17.2%	206			
Lake/Pond	16	0.0%	12	SUB TOTAL	29,076	72.1%
Watercourse	993	2.5%	41	**MINI-BASIN AREA**	**40,320**	
SUB-TOTAL	11,244	27.9%	340	Source: Leskiw (1986), p. 15.		

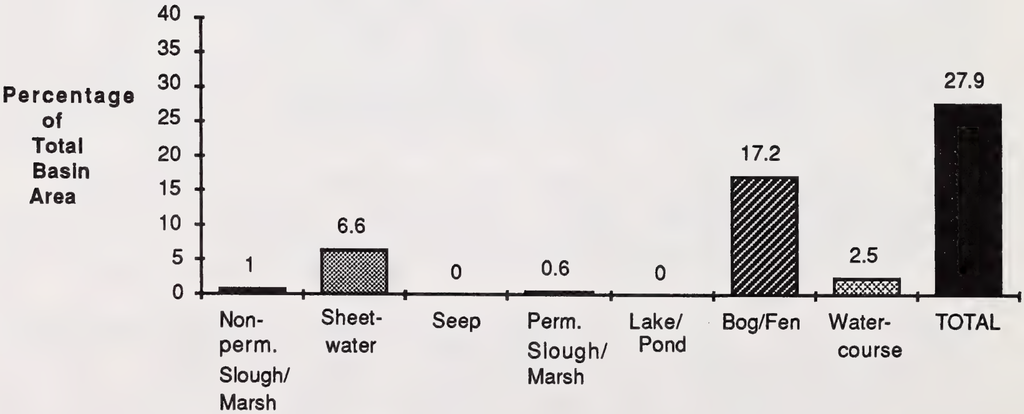
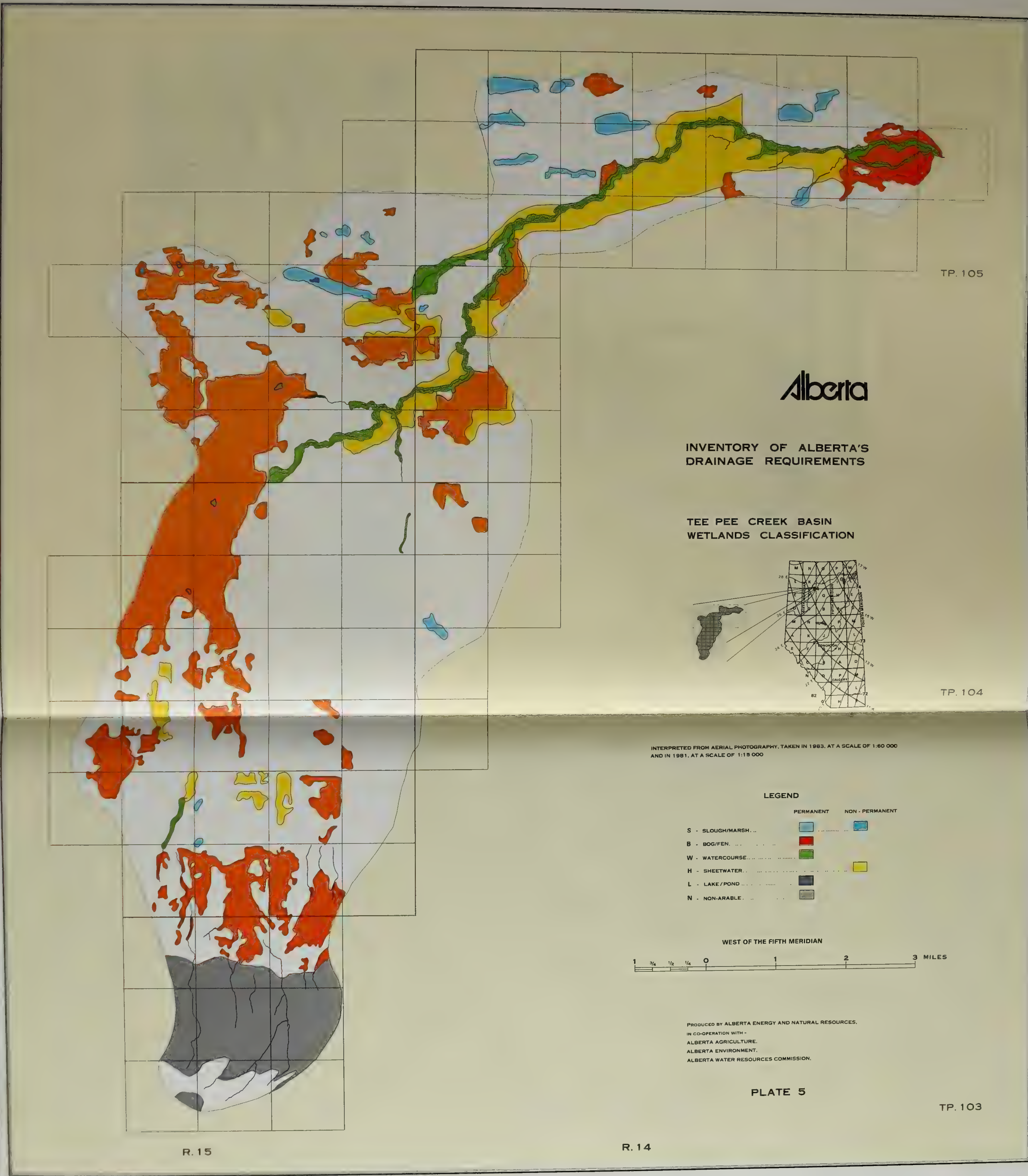


Figure 3.7 TEE PEE CREEK MINI-BASIN WETLAND DISTRIBUTION


TP. 105
TP. 104
TP. 103
R. 15
R. 14
INVENTORY OF ALBERTA'S
DRAINAGE REQUIREMENTS
TEE PEE CREEK BASIN
WETLANDS CLASSIFICATION
INTERPRETED FROM AERIAL PHOTOGRAPHY, TAKEN IN 1983, AT A SCALE OF 1:60 000
AND IN 1981, AT A SCALE OF 1:15 000
LEGEND
PERMANENT
NON - PERMANENT
S - SLOUGH/MARSH
B - BOG/FEN
W - WATERCOURSE
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N - NON-ARABLE
WEST OF THE FIFTH MERIDIAN
1 3/4 1/2 1/4 0 1 2 3 MILES
PRODUCED BY ALBERTA ENERGY AND NATURAL RESOURCES,
IN CO-OPERATION WITH -
ALBERTA AGRICULTURE,
ALBERTA ENVIRONMENT,
ALBERTA WATER RESOURCES COMMISSION.
PLATE 5

Table 3.14

TEE PEE CREEK FARM FINANCIAL ANALYSIS
(present value over 30 years)

DRAINAGE SCENARIO	Acres Drained per Average Section	AVERAGE ANNUAL COSTS*	AVERAGE ANNUAL BENEFITS**	AVERAGE ANNUAL NET RETURN
		- $ per acre drained-		
TOTAL DRAINAGE	162.7	76	100	24
PARTIAL DRAINAGE	48.4	59	103	44
CONSOLIDATION	48.4	160	164	4

* includes initial capital costs
** this includes both production revenue and financing to cover the capital cost

Table 3.15

TEE PEE CREEK PUBLIC DIRECT BENEFITS AND COSTS
(present value over 30 years)

NET PRESENT VALUE***	BENEFITS	INVESTMENT COSTS			TOTAL INVESTMENT COSTS	NPV*** WITH WILDLIFE MITIGATION	NPV*** WITHOUT WILDLIFE MITIGATION
	Gross Margin**	On-Farm Drainage	Off-Farm Drainage	Wildlife Mitigation*			
$/ACRE DRAINED							
Total Drainage	622	138	535	343	1,016	-394	-51
Partial Drainage	1,136	106	554	862	1,522	-386	476
Consolidation	1,000	1,044	0	69	1,113	-113	-44
TOTAL ($ thousands)							
Total Drainage	6,371	1,415	5,485	3,511	10,411	-4,040	-529
Partial Drainage	3,467	323	1,690	2,631	4,644	-1,177	1,454
Consolidation	3,053	3,186	0	211	3,397	-344	-133

* 100 percent wildlife mitigation
** Gross Margin = gross farm receipts minus production costs
*** Net Present Value (NPV) = Gross Margin minus total investment costs

3.5 Discussion and Conclusions

3.5.1 Wetlands of the Mini-Basins

As illustrated in Figure 3.8, the five mini-basin areas exhibit a variety of wetland conditions and densities. There are two major types of wetland distribution encountered in these study areas: (1) those dominated by non-permanent wetlands, either slough/marsh (Silver and Dunvegan Creeks) or sheetwater (Lalby Creek), and (2) those dominated by bog/fen (Shoal and Tee Pee Creeks). The first type of wetland distribution is found in the mini-basins with a high percentage of cultivated land. For Silver, Dunvegan and Lalby Creek mini-basins, cultivated area accounts for 78, 69 and 61 percent of each basin respectively.

Bog/fen wetlands are associated with mini-basins that are less developed. Shoal and Tee Pee Creek mini-basins have only 55 and 48 percent respectively of the basin area in cultivation. Expansion of the agricultural land base involves clearing and draining of large areas of bog/fen.

3.5.2 Soils and Agronomy

Most of the crop production increase from drainage is from cultivation of former wetland areas. There are also smaller increases resulting from improvements in upland areas adjacent to drained land. Crop production differences among mini-basins reflect both agroclimatic factors and the dispersion of their wetlands. There are more upland benefits in areas where wetlands are small and numerous.

3.5.3 On-Farm Drainage Engineering

The cost of on-farm drainage varies depending upon the combination of wetland density and mix, and basin topography. Generally, the per acre costs of drainage are highest for small, deep wetlands in undulating topography such as in Silver Creek and lowest for large areas of bog/fen and sheetwater, as in Tee Pee, Shoal and Lalby Creeks (Table 3.16).

The least-cost drainage method also varies among wetlands. Sub-surface drainage is best suited to slough/marshes in areas of undulating topography, because surface ditches require deep excavation and sever cultivated fields. Surface ditches are least costly for large wetlands and shallow depths of excavation (less than two feet). Many can be cropped as part of the adjacent field.

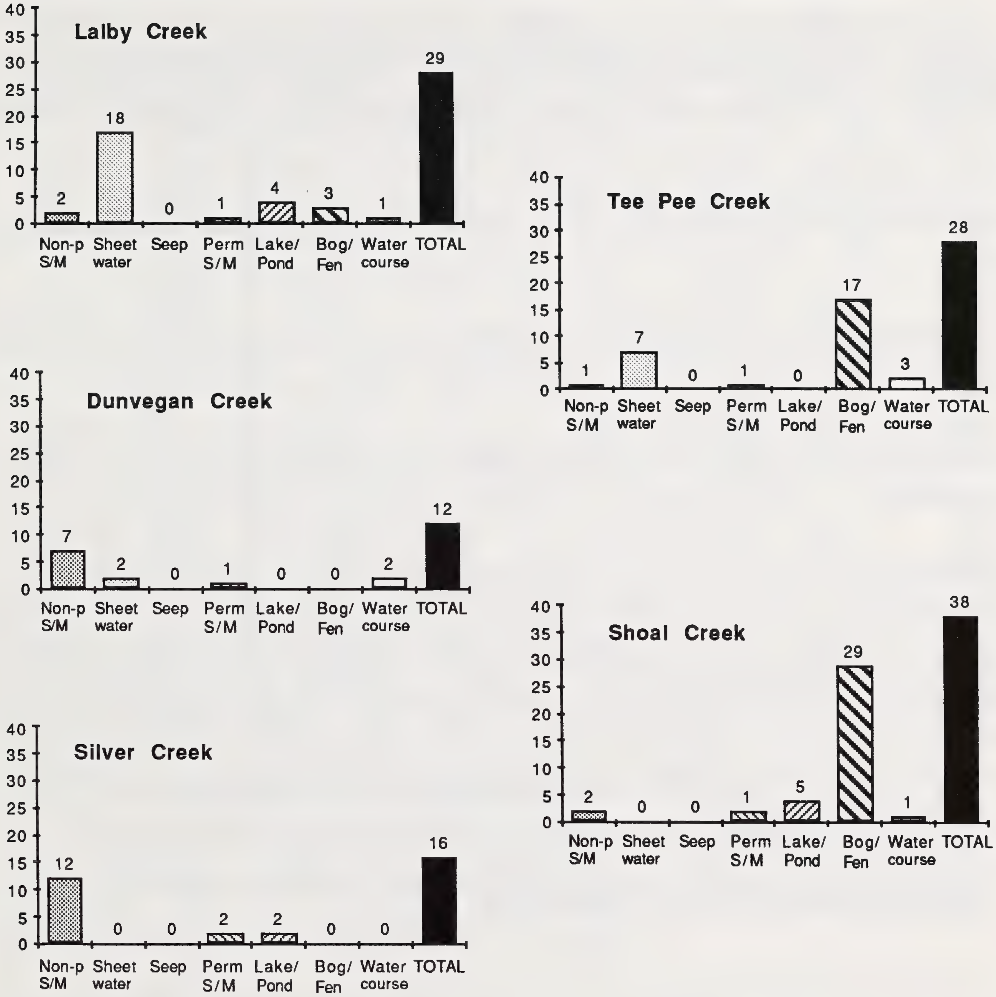

FIGURE 3.8 Wetland Distribution of Five Mini-Basins

Table 3.16

COSTS FOR DRAINAGE AND WILDLIFE MITIGATION IN THE FIVE MINI-BASINS

Basins and Drainage Scenarios	Acres Drained /Average Section	COSTS					TOTAL COSTS (Drainage + Mitigation)
		On-Farm Drainage	Off-Farm Drainage [1]	Construction of Consolidation Ponds [2]	SUB-TOTAL DRAINAGE COSTS	WILDLIFE MITIGATION (100 %) [3]	
		----------($ per acre drained, present value)---------					
SILVER							
Total	100.0	745	464	0	1,209	3,013	4,222
Partial	75.5	630	614	0	1,244	2,534	3,778
Consolidation	75.5	630	0	1,002	1,632	507	2,139
SHOAL							
Total	210.3	187	355	0	542	228	770
Partial	10.2	447	1,315	0	1,762	2,030	3,792
Consolidation	10.2	447	0	978	1,425	626	2,051
LALBY							
Total	90.8	176	249	0	425	68	493
Partial	70.0	88	290	0	378	79	457
Consolidation	70.0	88	0	391	479	42	521
DUNVEGAN							
Total	64.5	402	2,357	0	2,759	2,046	4,805
Partial	57.8	336	2,628	0	2,964	1,869	4,833
Consolidation	57.8	336	0	967	1,303	309	1,612
TEE PEE							
Total	162.7	138	535	0	673	343	1,016
Partial	48.4	106	554	0	660	862	1,522
Consolidation	48.4	106	0	938	1,044	69	1,113

Notes

[1] Off-farm ditches with flow restriction at each farm (controlled drainage). Includes operation and maintenance costs over 30 years.

[2] Incremental costs (in addition to on-farm drainage) required to store and slow release drainage water on each farm.

[3] Total mitigation by enhancement of permanent wetlands and creation of new habitat (not including mitigation for drainage of bog/fen or sheetwater areas).

3.5.4 Hydrotechnical Effects and Off-Farm Drainage Works

The effect of drainage on the hydrologic system of each mini-basin, hence the level and cost of off-farm drainage work required, is related to three factors:

1. The storage capacity and overflow potential of the wetlands. The smaller the storage capacity, the greater and quicker the response to rainfall and snowmelt. The smallest increases in peak flows will occur in areas where the wetlands provide little natural storage and maximum overflow potential such as sheetwater in Lalby Creek. These are reflected in the low costs shown in Table 3.16. In contrast, the greatest flow increases resulting from drainage will occur in areas where the wetlands provide maximum storage and minimal overflow potential, such as the slough/marshes of Silver Creek.

2. The dispersion of the wetlands. The per acre off-farm cost is greatest for partial drainage of relatively few, isolated non-permanent wetlands in Shoal Creek.

3. The erosion potential of the watercourses, which varies with soil stability, gradient and water velocity. High erosion protection costs, over $2,600 per acre drained, were estimated for Dunvegan Creek where the soils are unstable and the slopes steep.

It is obvious from these results that off-farm costs decrease with greater control of drainage flows at the farm level. As shown in Table 3.17 off-farm costs for controlled drainage are significantly less than for uncontrolled drainage. Because of these differences, some form of on-farm or upstream control should be considered wherever practical in regional drainage project designs. For areas of northern Alberta with significantly higher snowmelt runoff flows than summer storm flows, off-farm drainage designs must include optimally sized culverts to control the rate of spring runoff, yet prevent prolonged flooding of fields.

Controlled drainage can be achieved without causing crop degradation, by using subsurface drainage systems or by downsizing culverts. If used in conjunction with farm ditches with gentle side slopes, the farmer can crop the drainage ditch for at least part of its length.

In areas such as Tee Pee Creek, off-farm costs could be reduced by discharging or consolidating drainage water on nearby undeveloped Crown lands which are dominated by bog/fen wetlands. Before these public lands are released for development, consideration should be made of their potential for these uses. The clearing of private and public lands in upstream locations in northern Alberta has caused flooding and erosion in downstream agricultural and municipal areas.

These studies have predicted the potential downstream impacts from different levels and locations of drainage within a small watershed. This approach may prevent costly rehabilitation of downstream off-farm channels because potential inflows from all areas are considered in the original design. Before a more detailed level of design is carried out for these mini-basins

and other comparable areas, a number of refinements, including detailed calibration to Alberta conditions, will be required. Preliminary work in this area is currently underway by Alberta Environment.

Assuming farmer acceptance, on-farm retention of drainage water may be less costly than conventional off-farm drainage where there are high erosion protection costs as in Dunvegan Creek, or where non-permanent wetlands are few and scattered, as in Shoal Creek.

Table 3.17

COMPARISON OF OFF-FARM DRAINAGE CAPITAL COSTS FOR CONTROLLED AND UNCONTROLLED DRAINAGE

MINI-BASIN	DRAINAGE SCENARIO	CONTROLLED	UNCONTROLLED
		($ per acre drained)**	
Silver	Partial drainage	1,100	2,620
Shoal	Total drainage	286	607
Lalby	Partial drainage	209	954
Dunvegan	Partial drainage*	2,131	2,770
Tee Pee	Total drainage	386	1,090
Tee Pee	Partial drainage	400	1,540

* with on-stream storage
** does not include operation and maintenance costs

SOURCE: W-E-R Engineering Ltd. (1987)

All the off-farm drainage cost estimates assume there would be drainage of all identified wetlands, requiring a comprehensive drainage network to serve each section. With reduced levels of drainage, costs per acre drained are higher and the net economic returns are reduced for off-farm drainage (W-E-R Engineering Ltd. 1987). Total costs per acre drained are unaffected by extent of drainage for the consolidation option which requires no extensive off-farm drainage network, and therefore can be implemented on a farm by farm basis.

3.5.5 Wildlife, Fisheries and Other Environmental Considerations

3.5.5.1 Wildlife. Wetlands provide habitat for a large variety of plant and animal species and also provide important functions in the hydrologic cycle. Mitigation, involving the enhancement and development of wetlands other than the ones drained, helps to prevent losses of these uses when drainage is implemented. Different wetland types, such as those described in this study have different values to wildlife. The mitigation costs, which were determined only on the basis of replacing the habitat value and not the hydrologic functions, vary from basin to basin depending on the amount and quality of the habitat which would be lost. For both the total and partial drainage scenarios, mitigation was assumed to occur outside the mini-basin. While this provides a method for determining costs, it is not a feasible

alternative since it would involve taking land out of production in one basin to create good habitat, while draining land to put it into production in another basin. In productive agricultural areas under the total drainage scenario, it is probable that no land would be available for mitigation. The consolidation scenario presents the best option for mitigation since the habitat remains in the same specific area.

Waterfowl is the group most seriously affected by drainage but bog/fen shorebirds (species such as snipe), upland gamebirds, ungulates and small, ground dwelling birds and animals would also be affected. Approximately 16 million ducks are produced in this province each year, about 70 percent of them in the agricultural areas of central and northern Alberta. Total and partial drainage in this area without consolidation or mitigation would markedly reduce this number.

The costs per acre drained (Table 3.16) vary considerably from basin to basin but in all cases the costs to mitigate in the consolidation scenario are significantly less (from two to 12 times) than those for partial drainage (which drains the same number of acres). Costs are highest for mini-basins which have a large proportion of slough/marsh wetlands as this is the best rated habitat for many species and mitigation costs are included for all acres drained. Mitigation costs for bog/fen and sheetwater areas were not included in the analyses, hence for those mini-basins with a high proportion of these wetland types the costs are relatively low.

Replacing non-permanent wetlands lost through drainage with enhanced consolidation ponds or permanent wetlands, may not provide the diversity of habitat required by some species. A wetland habitat mix of 30 percent seasonal water, 20 percent permanent water and 50 percent upland/meadow areas provides for good interspersion of water depths, and wetland and upland vegetation. This habitat combination could be provided where pond levels could be manipulated to provide peripheral seasonal habitat. Regional consolidation areas with this type of operating flexibility could represent significant opportunities for wildlife habitat mitigation.

The establishment of wildlife mitigation areas would require long-term control of the land to ensure future protection of the habitat developed. This would probably involve long-term lease agreements.

3.5.5.2 Fisheries. None of the mini-basins studied had fisheries potential in the wetlands or the creek; however, the receiving streams for these basins provide fish habitat. The impacts, in terms of changes in flow regime and water quality, of draining any one mini-basin are not likely to be significant. The cumulative effect if many small watersheds were drained would likely be significant.

3.5.5.3 Other Environmental Considerations. Mitigation costs calculated in this study do not take into account other services provided by wetlands such as groundwater recharge, flow regulation, water quality control and reduced sedimentation. The consolidation option provides a viable mechanism for retaining these benefits.

Consolidation, because it provides opportunities for flow control and water quality improvements, would have the least negative impact on

fisheries of any drainage scenario. It could provide positive benefits such as flow augmentation during low oxygen or low flow periods, and opportunities for put-and-take fisheries thereby enhancing local recreation possibilities. Consolidation ponds can also provide for on-farm uses such as domestic water use, stock watering and irrigation.

A major requirement will be public acceptance of on-farm consolidation. In some cases, limited scale consolidation may be attractive to farmers on the basis of the above on-farm benefits. However, in order to achieve widespread control of downstream flows and significant wildlife habitat benefits, public financial and technical assistance will be required.

It may also be possible to achieve downstream flow control and wildlife habitat benefits by consolidating drainage water regionally on public lands. This would also require testing, demonstration and public financial support.

3.5.6 Economics

3.5.6.1 Farm Financial. Partial drainage is financially viable in all five mini-basins and more attractive than total drainage because it is more expensive to drain permanent wetlands and put them into agricultural production (Table 3.18). These results explain the demand for drainage in central Alberta. On-farm consolidation for multi-purpose water use is not financially attractive to farmers if they must pay the entire cost of pond construction.

3.5.6.2 Public Direct Benefits and Costs. Table 3.19 presents the results of the public direct benefits and costs analysis which indicate that from a societal viewpoint, drainage is economically viable only in Lalby Creek because of the low costs of drainage and wildlife mitigation. For all the other mini-basins, if wildlife mitigation costs are included drainage is not economically feasible. Consolidation is the best option in all the mini-basins except Lalby Creek.

If wildlife habitat mitigation costs are excluded, economic feasibility is improved, though only in a few cases does it become positive. It should be recognized, however, that positive direct net benefits is not the only criterion for judging drainage, nor does the exclusion of habitat mitigation costs mean that the threatened wildlife has no public value.

Table 3.18

SUMMARY OF FARM FINANCIAL ANALYSIS
Average Annual Net Return

DRAINAGE SCENARIO	SILVER CREEK	SHOAL CREEK	LALBY CREEK	DUNVEGAN CREEK	TEE PEE CREEK
	---------- $ per acre drained ----------				
TOTAL DRAINAGE -drain all wetlands	26	6	27	41	24
PARTIAL DRAINAGE -drain non-permanent wetlands	45	16	54	41	44
CONSOLIDATION -drain & consolidate non-permanent wetlands	-32	-115	-6	-24	4

* expressed as the present value of projected 30 year costs and benefits

Table 3.19

SUMMARY OF PUBLIC DIRECT BENEFITS AND COSTS*
Net Present Value ($)

NET PRESENT VALUE	SILVER CREEK	SHOAL CREEK	LALBY CREEK	DUNVEGAN CREEK	TEE PEE CREEK
$ PER ACRE DRAINED					
Total Drainage	-2,840	-360	70	-3,610	-390
Partial Drainage	-2,170	-2,630	140	-3,680	-390
Consolidation	-760	-820	50	-590	-110
TOTAL ($ million)					
Total Drainage	-15	-8	1	-14	-4
Partial Drainage	-9	-4	1	-13	-1
Consolidation	-3	-1	0	-2	0

* expressed as the present value of projected 30 year costs and benefits, with 100 percent wildlife mitigation

4. DRAINAGE POTENTIAL AND CONSTRAINTS

4.1 Introduction

As outlined in previous chapters, the Phase II inventory provided estimates by wetland type for each river basin in Alberta, whereas the mini-basin studies were comprehensive investigations of five representative drainage situations. In this chapter, these two major components are integrated to outline the drainage potential and constraints of the five northern river basins: the Battle, North Saskatchewan, Beaver, Athabasca and Peace.

The total drainage option is not included in the river basin analysis as it was not considered desirable for economic, environmental and practical reasons. The estimated cost for total drainage over a 100 year period is $2.1 billion without wildlife mitigation and $3.6 billion with wildlife mitigation, excluding mitigation of bog/fen and sheetwater wetlands. Corresponding costs for partial drainage are much less; $700 million and $1.6 billion without and with mitigation respectively.

It is important to note that the following discussion provides general background information for the purposes of regional level policy and program planning. Because wide variation in drainage conditions can exist within a region, integrated planning on a small watershed basis is a realistic approach to drainage at the local level.

4.2 River Basin Comparison

As indicated in Table 2.4, over 75 percent of the wetland in Alberta is found in the five northern river basins. This amounts to a total acreage of 9.5 million acres, dominated by 5.6 million acres of bog/fen. Some drainage of bogs and fens is occurring in central and northern Alberta, and it is estimated that up to 50 percent of this large area has agricultural potential (based on personal communication with Alberta Agriculture regional staff in these areas). Research is required, however, to refine this estimate because of the wide variation in drainage, soil and vegetation characteristics of these wetlands.

Non-permanent wetlands account for 2.1 million acres, about 85 percent of which are non-permanent slough/marsh. Most of these are found within productive, cultivated land and their drainage is financially attractive to farmers. About 300,000 acres of sheetwater are distributed in the cultivated areas of the Peace and Athabasca river basins. There is considerable interest in draining sheetwater wetlands because they directly affect cultivated fields and are relatively inexpensive to drain.

Tables 4.1 to 4.5 and Figures 4.1 to 4.5 present the wetland inventory results for each river basin. There are significant differences in wetland density and types from central to northern Alberta. The amount of wetland acreage in each river basin increases from 12 percent in the Battle River

and 21 percent in the North Saskatchewan River to over 30 percent in the three northern basins. The type of wetland also changes significantly; from a predominance of non-permanent wetlands (primarily sloughs) in the Battle and North Saskatchewan basins to a predominance of bogs and fens in the three northern river basins.

4.2.1 Battle River Basin

The Battle River basin in central Alberta, with the most favourable agro-climatic conditions, has the highest degree of agricultural development of the five basins. It has the lowest density of wetlands, which occupy just over one million acres or 12 percent of the basin area (Table 4.1 and Figure 4.1). Non-permanent sloughs occupy over eighty percent of the wetland area of the basin. Drainage of these is extensive, prompted largely by farmers' interests to remove them to improve farm efficiency and increase crop yields. The conclusions of the Silver Creek mini-basin studies apply to the Battle River basin because of similar agricultural conditions and wetland distributions.

Table 4.1
BATTLE RIVER BASIN
WETLAND ACREAGE

WETLAND AREA ('000 acres)			
NON-PERMANENT		**PERMANENT**	
Slough/Marsh	830	Slough/Marsh	29
Sheetwater	0	Lake/Pond	57
Seep	6	Bog/Fen	0
		Watercourse	87
SUB-TOTAL	836	**SUB-TOTAL**	173
WETLAND TOTAL		**1,009,000 acres**	

CURRENT DRAINAGE ACTIVITY AND PROBLEMS:
-intensive drainage of temporary slough/ marsh
-some downstream flooding experienced
WHITE ZONE AREA = 8,317,000 acres

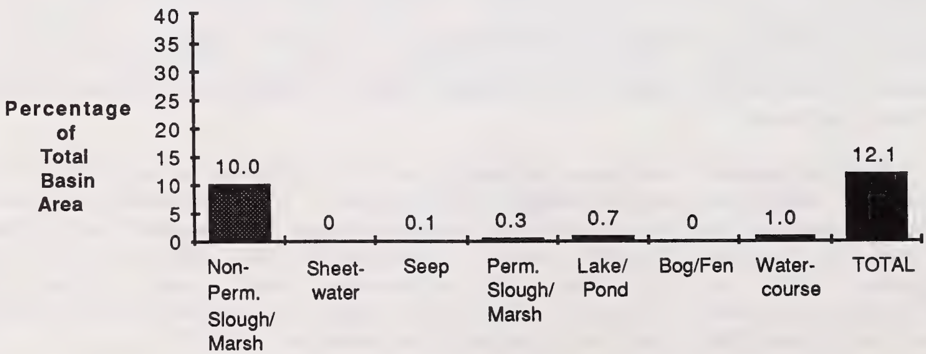

Figure 4.1 BATTLE RIVER BASIN WETLAND DISTRIBUTION

4.2.2 North Saskatchewan River Basin

Approximately 1.8 million acres or 21 percent of the North Saskatchewan River basin's agricultural area is covered by wetlands (Table 4.2 and Figure 4.2). The major wetland types are temporary slough/marsh and bog/fen. Most of the temporary sloughs occur within the agriculturally developed part of the basin, in the eastern region between Edmonton and the Saskatchewan border. The conclusions for the Silver Creek mini-basin apply to this portion of the basin. Other parts of the North Saskatchewan River basin resemble the Shoal Creek mini-basin near Westlock which has a wetland acreage dominated by bog/fen. The conclusions from the Shoal Creek studies, therefore, apply to the less developed areas of the North Saskatchewan river basin.

Table 4.2
NORTH SASKATCHEWAN RIVER BASIN WETLAND ACREAGE

WETLAND AREA ('000 acres)			
NON-PERMANENT		**PERMANENT**	
Slough/Marsh	803	Slough/Marsh	91
Sheetwater	0	Lake/Pond	114
Seep	0	Bog/Fen	563
		Watercourse	246
SUB-TOTAL	803	**SUB-TOTAL**	1014
WETLAND TOTAL		**1,817,000 acres**	

CURRENT DRAINAGE ACTIVITY AND PROBLEMS:
-large proportion of basin's wetland is temporary slough/marsh
-considerable drainage of those wetlands
-expansion into organic soils
WHITE ZONE AREA = 8,663,000 acres

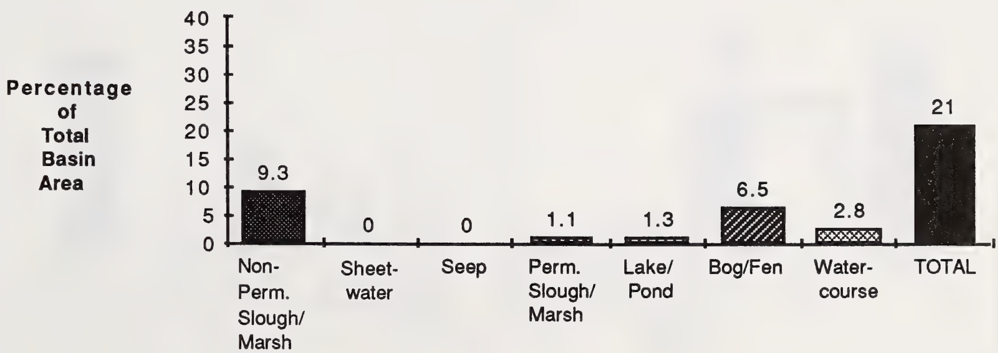

Figure 4.2 NORTH SASKATCHEWAN RIVER BASIN WETLAND DISTRIBUTION

4.2.3 Beaver River Basin

The Beaver River basin area has over 800,000 acres or 35 percent of its agricultural land base classified as wetland (Table 4.3 and Figure 4.3). However only a small percentage of its wetlands are non-permanent; most of the wetlands are either bog/fen or lake/pond. The Shoal Creek mini-basin is a good representation of the Beaver River basin because it has a high wetland density, a predominance of bog/fen and a similar proportion of slough/marsh.

Table 4.3
BEAVER RIVER BASIN
WETLAND ACREAGE

WETLAND AREA ('000 acres)			
NON-PERMANENT		**PERMANENT**	
Slough/Marsh	37	Slough/Marsh	50
Sheetwater	0	Lake/Pond	258
Seep	0	Bog/Fen	405
		Watercourse	59
SUB-TOTAL	37	**SUB-TOTAL**	772
WETLAND TOTAL		**809,000 acres**	

CURRENT DRAINAGE ACTIVITY AND PROBLEMS:
-large proportion of basin has bog/fen - drainage occurring as part of agricultural land expansion -large percentage of lake/pond but limited drainage
WHITE ZONE AREA = 2,327,000 acres

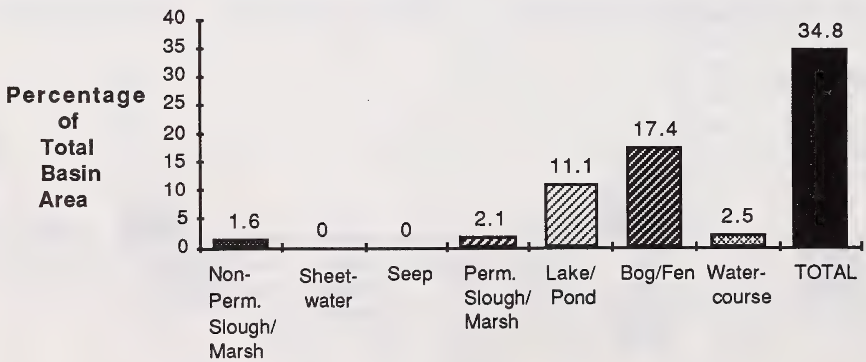

Figure 4.3 BEAVER RIVER BASIN WETLAND DISTRIBUTION

4.2.4 Athabasca River Basin

The Athabasca River Basin has the highest density of wetlands of the five northern basins, occupying about 37 percent of the basin's agricultural area (Figure 4.4). Most of the almost 2 million acres of wetlands is bog/fen with much smaller acreages of permanent lake/pond and sheetwater (Table 4.4). The results of three mini-basins apply to this basin: Shoal Creek, because much of its wetland composition is similar to the Athabasca River basin, and Tee Pee and Lalby Creeks because they have sheetwater areas.

Table 4.4
ATHABASCA RIVER BASIN
WETLAND ACREAGE

WETLAND AREA ('000 acres)			
NON-PERMANENT		**PERMANENT**	
Slough/Marsh	52	Slough/Marsh	84
Sheetwater	110	Lake/Pond	208
Seep	0	Bog/Fen	1,460
		Watercourse	82
SUB-TOTAL	162	**SUB-TOTAL**	1,834
WETLAND TOTAL		**1,996,000 acres**	

CURRENT DRAINAGE ACTIVITY AND PROBLEMS:
-expansion into organic soils a major activity
-some sheetwater (flooding of fields)
-limited drainage of temporary slough/marsh
WHITE ZONE AREA = 5,391,000 acres

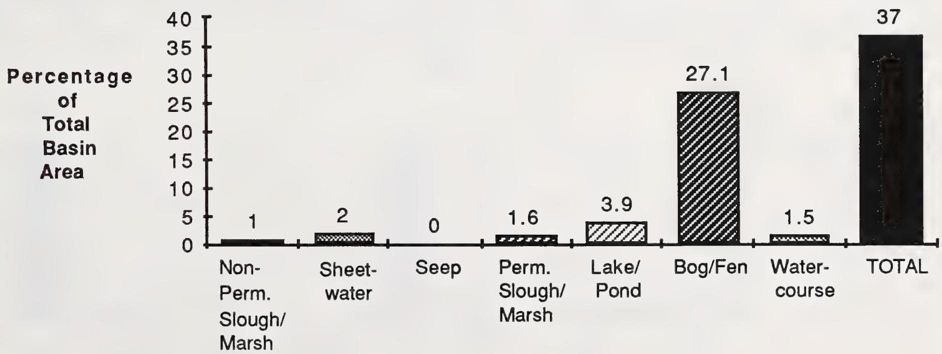

Figure 4.4 ATHABASCA RIVER BASIN WETLAND DISTRIBUTION

4.2.5 Peace River Basin

The Peace River Basin has about 3.6 million acres of wetlands, over 3 million of which is classified as bog/fen (Table 4.5 and Figure 4.5). There are almost 300,000 acres of non-permanent wetlands found mainly in the more developed southern half of the basin. Sheetwater makes up two-thirds of this acreage.

Four mini-basins exhibit conditions found in the Peace River basin: Shoal, Tee Pee, Lalby and Dunvegan. Shoal and Tee Pee Creek mini-basins resemble much of the northern and eastern portions of the Peace River basin, and Lalby Creek is representative of flat cultivated areas where sheetwater is a problem. In addition, almost 20 percent of the Peace River basin has high erosion potential because of unstable soils and steep topography, as found in the Dunvegan Creek mini-basin.

Table 4.5
PEACE RIVER BASIN
WETLAND ACREAGE

WETLAND AREA ('000 acres)			
NON-PERMANENT		**PERMANENT**	
Slough/Marsh	75	Slough/Marsh	14
Sheetwater	205	Lake/Pond	71
Seep	0	Bog/Fen	3,062
		Watercourse	389
SUB-TOTAL	280	**SUB-TOTAL**	3,536
WETLAND TOTAL		**3,816,000 acres**	

CURRENT DRAINAGE ACTIVITY AND PROBLEMS:
-expansion of agricultural land base in northern portion, involving drainage of large areas of bog/fen -sheetwater a problem in developed areas -drainage of temporary wetlands in Grande Prairie area, erosion control a major problem
WHITE ZONE AREA = 11,244,000 acres

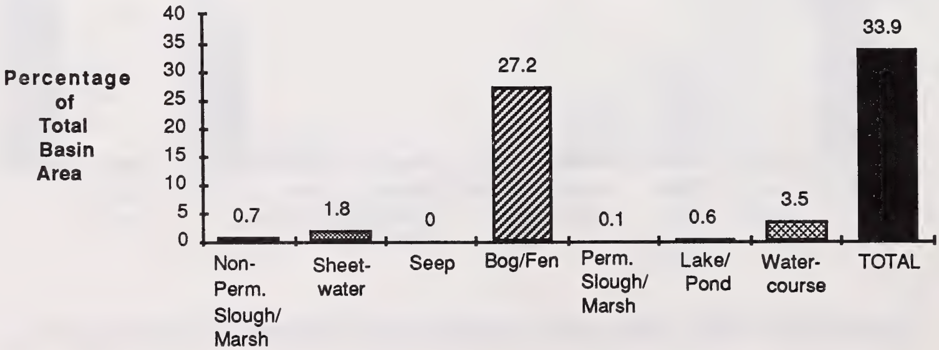

Figure 4.5 PEACE RIVER BASIN WETLAND DISTRIBUTION

4.3 Implications to Wildlife and Fisheries

Partial drainage will result in losses of wildlife habitat for most species but will especially affect waterfowl populations. The 10 year average (1973-82) provincial duck population is 16.8 million of which 70 percent (11.3 million) are produced in the five northern basins. Habitat losses from partial drainage in these basins will result in the loss of 9.1 million birds or 80 percent of the regional population (pers. comm. staff of Fish and Wildlife Division).

Non-permanent wetlands in agricultural areas generally have little direct value for fish populations. Changes in flow, sediment levels and chemical components in receiving streams resulting from drainage could have a negative effect, especially if wide-scale drainage takes place.

There is potential to mitigate negative effects on wildlife and fish habitat through drainage techniques such as consolidation.

4.4 Economic Implications of Drainage

4.4.1 Methods

Using the agronomic and economic data generated in the mini-basin studies, three economic analyses (farm financial, public direct benefits and costs and growth in the provincial economy) were carried out to determine the costs and benefits of drainage at the river basin level. The methods used in these analyses are described in section 3.3.6. They are consistent with those used in the Agricultural Land Base Study and are described in more detail in two economic analysis and impact reports (MacDonald-Date et al. 1986; Alberta Agriculture 1986) prepared for the Agricultural Land Base Study. The economic analyses are based on off-farm costs for controlled drainage flows, as uncontrolled drainage is significantly more expensive to accommodate, especially in erosion prone areas (section 3.5.4).

For each river basin, the three economic analyses extrapolate the results of one or more of the mini-basins exhibiting similar wetland types and proportions. The mix of mini-basins used has been determined mathematically using a linear programming model. As shown in Table 4.6, the Battle River basin is represented by the Silver Creek mini-basin, and the Beaver River basin by the Shoal Creek mini-basin. The other three river basins are represented by combinations of three mini-basins. It must be remembered that the results based on these combinations mask the variation that was evident in the mini-basin studies.

Two methods were used to quantify the wildlife-related value of wetlands: wildlife habitat mitigation costs as determined in the mini-basin studies (see section 3.3.5.1) and foregone hunting and trapping benefits if drainage proceeds without mitigation. The latter approach was used in the Agricultural Land Base Study; the methods are described in Asafu-Adjaye et al. (1986).

Table 4.6

MINI-BASIN COMBINATIONS USED FOR EXTRAPOLATION TO RIVER BASINS
(expressed as percent of total)

Representative Mini-basin	RIVER BASIN				
	PEACE	ATHABASCA	BEAVER	NORTH SASK.	BATTLE
Silver	0	0	0	76.4	100
Shoal	59.4	87.2	100	20.1	0
Lalby	0	5.7	0	0	0
Dunvegan	17.8	0	0	0	0
Tee Pee	22.8	7.1	0	3.5	0
Totals	100	100	100	100	100

Table 4.7

AVERAGE ANNUAL FARM FINANCIAL RETURNS
(After financing and income tax*)

RIVER BASIN	Partial Drainage	Consolidation
	----($ / acre drained / year)----	
Peace	27	-75
Athabasca	20	-102
Beaver	16	-116
North Sask.	39	-60
Battle	45	-48

* After production and on-farm drainage costs are considered. Benefits from improved production in upland areas are attributed to drained wetland acres.

NOTES: The detailed methods used to generate these numbers appear in "Agricultural Land Base Study - Economic and Financial Analysis: Direct Benefits and Costs" by Production and Resource Economics Branch, Economic Services Division, Alberta Agriculture. These values are based on the mini-basin results, with a number of adjustments.

4.4.2 Farm Financial Results

Table 4.7 summarizes for each of the five river basins, the average annual farm financial returns for partial drainage and consolidation. All of the analyses show a positive net return for partial drainage ranging from $16 per acre drained in the Beaver River basin to $45 per acre in the Battle River basin. It should be remembered that no off-farm drainage costs were included in this farm financial analysis. This option remains feasible in all basins even with a 20 percent reduction in benefits or a 20 percent increase in incremental costs. These results help to explain why farmers are draining wetlands, especially in the Battle River and North Saskatchewan River basins, where the net return on draining temporary sloughs is the most attractive. The farm financial returns for the consolidation option are negative because the farmer pays the entire construction cost of on-farm consolidation ponds.

4.4.3 Public Direct Benefits and Costs

Table 4.8 presents the results of the analysis of direct net benefits to society from partial drainage including benefits foregone for hunting and trapping. The Battle and North Saskatchewan river basins have the highest gross margin figures, reflecting the high potential agricultural productivity of the large acreages of non-permanent wetlands. These basins also have the highest drainage costs because of the high proportion of non-permanent wetlands. The hunting and trapping figures are considered low estimates of the wildlife related economic value of wetlands. This results from limitations in the available database that do not take into account the real distribution of wildlife populations and user activities. Additionally, the study (Asafu-Adjaye et al. 1986) considered only consumptive (hunting and trapping) values; but it has been estimated (Filion et al. 1983) that non-consumptive benefits are virtually equal to consumptive ones.

From Table 4.8 it can be concluded that drainage of 1.6 million acres of non-permanent wetlands in the Battle and North Saskatchewan river basins is economically viable if the economic losses for hunting and trapping are considered. Partial drainage in the three northern river basins is uneconomical, because of lower gross margins and high off-farm costs (especially for erosion control and drainage of widely scattered non-permanent wetlands).

Table 4.9 presents the analysis of net direct benefits to society from partial drainage including wildlife mitigation costs. Mitigation is most expensive for the Battle and North Saskatchewan river basins, reflecting the large acreages of non-permanent wetlands which have high wildlife habitat value. The net present values of drainage are negative for every basin studied and lowest for the North Saskatchewan and Battle river basins.

It is obvious from Tables 4.8 and 4.9 that the method of calculation of the wildlife related value of wetlands significantly affects the assessment of economic feasibility of drainage, especially in the basins of central Alberta where wetlands have high value for both wildlife and agriculture.

Table 4.10 presents the economic analysis for the consolidation option, assuming that pond construction and wildlife mitigation would occur on productive land. This reduces crop production and thus gross margin levels.

Table 4.8

PUBLIC DIRECT BENEFITS AND COSTS
PARTIAL DRAINAGE WITH LOST HUNTING AND TRAPPING BENEFITS*

RIVER BASIN	WETLAND AREA ('000) acres (White Zone)	Gross Margin**	On-Farm Drainage Costs	Off-Farm Drainage Costs	Benefits Foregone Hunting & Trapping	Net Present Value to Society
		------	($ million,	present	value)	---------
Peace	281	76.2	30.9	82.5	1.2	-38.4
Athabasca	163	42.1	21.7	42.2	1.0	-22.8
Beaver	37	9.4	5.5	10.4	0.3	-6.8
North Sask.	803	286.5	128.5	129.0	9.9	19.1
Battle	836	324.6	141.6	109.5	1.7	71.8
Total	2,120	738.8	328.2	373.6	14.1	22.9

* Drainage of non-permanent wetlands, calculated over 100 years
** Net farm receipts after costs

Table 4.9

PUBLIC DIRECT BENEFITS AND COSTS
PARTIAL DRAINAGE WITH COSTS OF 100 PERCENT WILDLIFE HABITAT MITIGATION*

RIVER BASIN	WETLAND AREA ('000) acres (White Zone)	Gross Margin**	On-Farm Drainage Costs	Off-Farm Drainage Costs	Wildlife Mitigation Costs	Net Present Value to Society
		------	($ million,	present	value)	---------
Peace	281	76.2	30.9	82.5	111.1	-148.3
Athabasca	163	42.1	21.7	42.2	72.6	-94.4
Beaver	37	9.4	5.5	10.4	18.5	-25.0
North Sask.	803	286.5	128.5	129.0	324.8	-295.8
Battle	836	324.6	141.6	109.5	327.6	-254.1
Total	2,120	738.8	328.2	373.6	854.6	-817.6

* Drainage of non-permanent wetlands, calculated over 100 years
** Net farm receipts after costs

Table 4.10

PUBLIC DIRECT BENEFITS AND COSTS
CONSOLIDATION WITH COSTS OF 100 PERCENT WILDLIFE HABITAT MITIGATION*

RIVER BASIN	WETLAND AREA ('000) acres (White Zone)	Gross Margin**	On-Farm Drainage Costs***	Off-Farm Drainage Costs	Wildlife Mitigation Costs	Net Present Value to Society
		------	($ million,	present	value)	---------
Peace	281	46.2	90.8	0	45.0	-89.6
Athabasca	163	20.2	56.2	0	32.8	-68.8
Beaver	37	4.1	13.5	0	8.3	-17.7
North Sask.	803	203.8	305.3	0	101.5	-203.0
Battle	836	245.5	327.3	0	86.9	-168.7
Total	2,120	519.8	793.1	0	274.5	-547.8

* Drainage and consolidation of non-permanent wetlands, calculated over 100 years
** Net farm receipts after costs
*** Including costs of consolidation ponds

Table 4.11

PUBLIC DIRECT BENEFITS AND COSTS
CONSOLIDATION ON AGRICULTURALLY NON-PRODUCTIVE LAND WITH 100 PERCENT WILDLIFE HABITAT MITIGATION*

RIVER BASIN	WETLAND AREA ('000) acres (White Zone)	Gross Margin**	On-Farm Drainage Costs***	Off-Farm Drainage Costs	Wildlife Mitigation Costs	Net Present Value to Society
		------	($ million,	present	value)	---------
Peace	281	76.2	90.8	0	45.0	-59.6
Athabasca	163	42.1	56.2	0	32.8	-46.9
Beaver	37	9.4	13.5	0	8.3	-12.4
North Sask.	803	286.5	305.3	0	101.5	-120.3
Battle	836	324.6	327.3	0	86.9	-89.6
Total	2,120	738.8	793.1	0	274.5	-328.8

* Drainage and consolidation of non-permanent wetlands, assuming no loss of gross margin (consolidation on non-productive land), calculated over 100 years
** Net farm receipts after costs
*** Including costs of consolidation ponds

The wildlife habitat mitigation costs average just over 30 percent of the costs for partial drainage. While net present values are still negative for each river basin, they are much better than for the partial drainage option.

Table 4.11 shows that consolidation is not economically attractive at the river basin level even if non-productive land is used for the ponds and wildlife mitigation. However, the figures for this option are much more favourable than those for partial drainage or consolidation on productive land.

At the river basin level, on-farm plus off-farm drainage costs are less for the consolidation option than for partial drainage (see Tables 4.8 to 4.11). This applies specifically to areas which have high erosion potential such as Dunvegan Creek mini-basin or few, isolated non-permanent wetlands, such as the Shoal Creek mini-basin.

5. STUDY CONCLUSIONS AND RECOMMENDATIONS

5.1 Major Study Conclusions

1. Approximately 12 million acres of wetlands are found in the agricultural area of Alberta. These wetlands represent about 20 percent of the total agricultural land base and their concentration ranges from five to 37 percent of the agricultural land in the major river basins. Over 75 percent of the wetland acreage is located in the five northern river basins: the Battle, North Saskatchewan, Beaver, Athabasca and Peace.

2. In these five basins, non-permanent wetlands (temporary slough/marsh and sheetwater) occupy approximately 2 million acres and have the highest potential for drainage. Bogs and fens (considered permanent) cover about 5.5 million acres, of which approximately half may be drainable given current technology. Other permanent wetlands (lake/pond, permanent slough/marsh and watercourse) were found in this study to be not drainable for economic and environmental reasons.

3. Drainage has a significant negative impact on wildlife, particularly where wetlands have a high habitat value. Continuation of current authorized and unauthorized drainage practices will seriously affect wildlife habitat. Drainage of the non-permanent wetlands of the five northern river basins would reduce waterfowl populations in the area by 80 percent (losses of 9.1 million ducks). This amounts to 54 percent of the total provincial population.

4. It is estimated that the present value of the costs to drain the non-permanent wetlands of the five northern river basins over a 100 year period would be approximately $1.6 billion, consisting of $330 million for on-farm drainage, $375 million for off-farm drainage works and $850 million for wildlife habitat mitigation.

5. From the farmer's perspective it is financially attractive to drain non-permanent wetlands, explaining why interest in drainage is high in these basins. On-farm consolidation was found to be financially unattractive to the farmer if he is required to pay all on-farm costs.

6. From a public perspective, when the costs of complete mitigation of habitat losses are included, drainage is economically feasible only in areas with a high proportion of sheetwater, regardless of which drainage scenario is considered. Consolidation is the lowest cost means of providing drainage and habitat mitigation.

7. From a public perspective, drainage of non-permanent wetlands is economically feasible if wildlife habitat mitigation costs are not included, erosion control costs are low or non-permanent wetlands are abundant. In cases where the erosion control costs are high or the non-permanent wetlands

are few and scattered, consolidation presents the least cost means of drainage.

8. In the Battle and North Saskatchewan river basins, drainage of non-permanent wetlands is economically feasible only if wildlife mitigation costs are not included. In the Peace, Athabasca and Beaver basins, however, generally higher erosion control costs or more scattered non-permanent wetlands make drainage economically infeasible. Within each river basin there would, however, be economically feasible projects at a smaller scale.

9. Control of drainage flow releases at the farm level significantly reduces off-farm drainage costs by reducing peak downstream flows. Capital costs for uncontrolled flows are up to 4.6 times greater than those for controlled. Unless drainage control at upstream locations is incorporated in future programs, the economics of drainage may be seriously affected.

10. Consolidation provides an opportunity to maintain other benefits provided by wetlands such as groundwater recharge, flow regulation and water quality control. Local land owner acceptance for such an option is necessary before consolidation could be practically implemented.

5.2 Major Study Recommendations

1. It is recommended that the government include drainage in interdepartmental water management plans for each major river basin. These would include technically sound long range designs, cost effective drainage development and natural resource conservation.

- Drainage planning should be initiated on a small watershed scale within the context of multi-purpose water use planning. The cumulative effects of draining several watersheds into the same receiving channel should be considered at the river basin level.

- Hydrotechnical modelling is required to estimate runoff conditions, especially related to farm size drainage projects. More comprehensive gauging of flows is required to calibrate the models, so that peak discharges and volumes can be accurately predicted.

2. It is recommended that existing program funding be provided to drainage only after adequate integrated planning has been completed.

- The use of interagency, multidisciplinary water resource planning programs with public involvement (such as the "Sub-basin Water Management Planning Program for Northwestern Alberta") should be continued and expanded to ensure adequate representation of agricultural, wildlife, water management, transportation and local government and public interests. This process should also be incorporated in the implementation phase.

3. It is recommended that during the sub-basin drainage planning process a detailed assessment of the potential drainage benefits and wildlife habitat losses should be included. If habitat is regionally important and drainage benefits are worthwhile, then public funding for appropriate levels of habitat mitigation should be provided for in the drainage process.

4. It is recommended that funding be provided for development and testing of drainage techniques which reduce downstream impacts and provide for wildlife habitat mitigation. These techniques would include controlled or choked drainage and on-farm and regional consolidation. When the practicality of such techniques is proven, the government should provide or redirect incentives for their implementation.

- The potential benefits of on-farm management and control of drainage water warrant research, particularly in areas of high erosion hazard, and where only a few scattered wetlands are to be drained.

5. It is recommended that when drainage costs are high because of the need for significant erosion control, downstream damage protection or extensive networks to drain a few, isolated wetlands; then standard off-farm drainage methods should be considered not viable. In these instances, and when the agricultural potential warrants, drainage alternatives such as consolidation should be considered for public funding.

- The government should consider financial and other incentives to landowners for wetland retention.

6. It is recommended that funding be provided for research on the classification, drainage, agronomic development and crop production potential of bog and fen wetlands.

- The productivity potential and optimal management of drained non-permanent wetlands should also be investigated. This would help farmers determine where drainage is most worthwhile and provide the government with information to assist drainage in the most appropriate locations.

7. It is recommended that the drainage potential and associated salinity problems of the southern portion of the province receive further study.

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APPENDIX A

STUDY PARTICIPANTS AND REPORTS

APPENDIX A

A.1 Project Managers

C. Surrendi (October 1983 to April 1985)
L. Kemper (Technical Assistant, October 1983 to April 1985)
L. Kemper (Project Manager, April 1985 to October 1985)
E. Jensen (Phase III Co-Ordinator, April 1985 to November 1986)
S. Bramm (Project Manager, October 1985 to November 1986)

A.2 Reports Prepared for this Study

All reports listed below can be reviewed in the Alberta Environment library. 14th floor, Oxbridge Place, 9820 - 106 Street, Edmonton, Alberta T5K 2J6. Telephone 427-5870. Those marked with an asterisk (*) can be reviewed in the following libraries:

Edmonton. Alberta Environment library. 14th floor, Oxbridge Place, 9820 - 106 Street, Edmonton, Alberta T5K 2J6. Telephone 427-5870.

Edmonton. Alberta Energy/Forestry, Lands and Wildlife library. 9th floor, South Tower, Petroleum Plaza, 9915 - 108 Street, Edmonton, Alberta T5K 2C9. Telephone 427-7425.

Edmonton. Alberta Agriculture library. Main floor, J.G. O'Donoghue Building, 7000 - 113 Street, Edmonton, Alberta T6H 5T6. Telephone 427-2104.

Edmonton. Alberta Water Resources Commission. #910 Harley Court Building, 10045 - 111 Street, Edmonton, Alberta T5K 2M5. Telephone 422-4232.

Lethbridge. Agriculture Canada library. Agriculture Centre, Jail Road, Lethbridge, Alberta T1J 4C7. Telephone 327-4561.

Calgary. Alberta Environment, Planning Division. Calgary, Alberta. Telephone 297-6270 (Mr. Dick Hart).

Grande Prairie. Alberta Environment, Planning Division. Grande Prairie, Alberta. Telephone 538-5350 (Mr. Nico Vander Giessen).

Peace River. Alberta Environment, Water Resources Administration Division. Peace River, Alberta. Telephone 624-6167 (Mr. Dene Berry).

A.2.1 Phase I

Intera Technologies Ltd. Sept. 1984a. Alberta Agricultural Wetlands Drainage Inventory: Phase 1 Aerial Photography Analysis and Ground Surveys. Volume 1: Final Report. Prepared by Intera Technologies Ltd. (Calgary), Jensen Engineering Ltd. (Olds) and Western Soils Consulting Ltd. (Lethbridge). Prepared for Interdepartmental Committee on Drainage. (Report B84-088). Calgary. 113 p., 25 tables, 25 figures, 56 references.

Intera Technologies Ltd. Sept. 1984b. Alberta Agricultural Wetlands Drainage Inventory: Phase 1 Aerial Photography Analysis and Ground Surveys. Volume 2: Appendices and Maps. Prepared by Intera Technologies Ltd. (Calgary), Jensen Engineering Ltd. (Olds) and Western Soils Consulting Ltd. (Lethbridge). Prepared for Interdepartmental Committee on Drainage. (Report B84-088). Calgary. p. 114 - 158, plus maps.

Intera Technologies Ltd. Sept. 1984c. Alberta Agricultural Wetlands Drainage Inventory: Phase 1 Landsat Evaluation. Prepared for Interdepartmental Committee on Drainage. . (Report B84-074). Calgary. 132 p. plus map transparencies, (appendices p. 90-114), 13 tables, 25 figures, 32 references.

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* Harrison, Robert P. May 1986. Extrapolation of Phase II Data. 51 p., 31 tables, 4 appendices.

Harron, Bill. March 1985. Inventory of Alberta's Drainage Requirements: Phase II- Ground Truth. Prepared for Interdepartmental Steering Committee on Drainage, Alberta Departments of Environment, Agriculture and Energy and Natural Resources. Edmonton, Western Soils Consulting Ltd. (File 11-84). 38 p. plus maps in back pocket, one table, two figures, 39 plates, three references.

* Intera Technologies Ltd. Oct. 1985. Final Report: Phase II Alberta Wetlands Drainage Inventory. Calgary. 58 p. (appendices p. 36-58) plus flight logs, 5 tables, 7 figures, 12 references.

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Jensen, Mike. 1986. Wetlands Project Report. Calgary, Riley's Datashare International Inc., 25 pages.

A.2.3 Phase IIIA

Andres, David et al. March 1984. Hydrologic Consequences of Land Drainage Phase 1: Literature Review. (Draft Final Report.) Edmonton, Alberta Research Council. 46 p., one table, 77 references.

Andres, David et al. Nov. 1984. Hydrological Impacts of Agricultural Land Drainage. Edmonton, Alberta Research Council. (Report No. SWE 84/03). 201 p., 19 tables, 68 figures, 131 references.

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A.2.4 Phase III - Mini-Basin Reports

A.2.4.1 Dunvegan Creek

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Fernet, D. A. July 1985. Inventory of Alberta's Drainage Requirements: Dunvegan Creek Basin. Fisheries Component. Prepared for the Interdepartmental Steering Committee on Drainage. Calgary, Environmental Management Associates. 19 p., one table, one figure, four references.

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Jensen Engineering Ltd. May 1985. Inventory of Alberta's Drainage Requirements: Dunvegan Creek Basin. Drainage Engineering Component. Prepared for the Interdepartmental Steering Committee on Drainage. 18 p. plus appendix, four tables, 18 figures.

Leskiw, L.A. Sept. 1985. Inventory of Alberta's Drainage Requirements: Dunvegan Creek Basin. Soils and Agronomy Component. Prepared for the Interdepartmental Steering Committee on Drainage. Edmonton, Pedology Consultants. 54 p. (appendices p. 47-54), 11 tables, 8 figures, 8 photos, 17 references.

W-E-R Engineering Ltd. (in association with JNMackenzie Engineering Ltd.). May 1985. Inventory of Alberta's Drainage Requirements: Dunvegan Creek Basin. Hydrology/Hydraulics Component. Prepared for the Interdepartmental Steering Committee on Drainage. Calgary. 31 p., 7 tables, one figure, 11 references.

A.2.4.2 Lalby Creek

Anderson, Marv. Nov. 1985. Inventory of Alberta's Drainage Requirements: Lalby Creek Basin. Economics Report. Prepared for the Interdepartmental Steering Committee on Drainage. Edmonton, Marv Anderson & Associates Ltd. 26 p., two tables, one figure, 21 references, 17 tables in appendix.

Fernet, D. A. March 1985. Inventory of Alberta's Drainage Requirements: Lalby Creek Basin. Fisheries Component. Prepared for the Interdepartmental Steering Committee on Drainage. Calgary, Environmental Management Associates. 18 p., one table, four references.

Green Jeffrey E. and R.E. Salter. Oct. 1985. Phase II An Inventory of Alberta's Drainage Requirements: Wildlife Component Lalby Creek. Prepared for the Interdepartmental Steering Committee on Drainage. Calgary, LGL Ltd. 71 p., 10 tables, one figure, 29 references.

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A.2.4.3 Shoal Creek

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Leskiw, L.A. Sept. 1985. Inventory of Alberta's Drainage Requirements: Shoal Creek Basin. Soils and Agronomy Component. Prepared for Interdepartmental Steering Committee on Drainage. Edmonton, Pedology Consultants. 59 p. (appendix p. 53-59), 12 tables, 5 figures, 6 photos, 24 references.

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A.2.4.4 Silver Creek

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A.2.4.5 Tee Pee Creek

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Fernet, D. A. Sept. 1985. Inventory of Alberta's Drainage Requirements: Tee Pee Creek Basin. Fisheries Component. Prepared for the Interdepartmental Steering Committee on Drainage. Calgary, Environmental Management Associates. 22 p., two tables, two figures, 7 references.

Green Jeffrey E. and R.E. Salter. Oct. 1985. Phase III An Inventory of Alberta's Drainage Requirements: Wildlife Component Tee Pee Creek. Prepared for the Interdepartmental Steering Committee on Drainage. Calgary, LGL Ltd. 68 p., 10 tables, one figure, 31 references.

Jensen Engineering Ltd. Sept. 1985. Inventory of Alberta's Drainage Requirements: Tee Pee Creek Basin. Drainage Engineering Component. Olds. 19 p., three tables, 13 figures.

Leskiw, L.A. Sept. 1985. Inventory of Alberta's Drainage Requirements: Tee Pee Creek Basin. Soils and Agronomy Component. Prepared for the Interdepartmental Steering Committee on Drainage. Edmonton, Pedology Consultants. 44 p., 11 tables, 6 figures, 11 references.

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A.2.5 Phase III Summary Reports

* Anderson, Marvin. (Marv Anderson and Associates Limited, Edmonton). 1987. Drainage Potential in Alberta: An Integrated Study. Technical Report 6: Economics Component. Alberta Environment, Alberta Agriculture and Alberta Forestry, Lands and Wildlife. 133 p., 28 tables, one figure, two appendices with numerous table, 21 references.

* Fernet, D.A. (Environmental Management Associates, Calgary). 1987. Drainage Potential in Alberta: An Integrated Study. Technical Report 5: Fisheries Component. Alberta Environment, Alberta Agriculture and Alberta Forestry, Lands and Wildlife. 38 p., 4 tables, one appendix, 19 references.

* Green, Jeffrey E. and R.E. Salter (LGL Limited, Calgary). 1987. Drainage Potential in Alberta: An Integrated Study. Technical Report 4: Wildlife Component. Alberta Environment, Alberta Agriculture and

Alberta Forestry, Lands and Wildlife. 174 p., 38 tables, one figure, 68 references.

Green, Jeffrey E., Salter, Richard E. and Carl R. Cooper (LGL Limited, Calgary). 1987. Habitat Assessment Models for Wetland-Associated Wildlife in Agricultural Areas of Alberta. Alberta Environment, Alberta Agriculture and Alberta Forestry, Lands and Wildlife.

* Jensen, N.E. and J.B. Wright (Jensen Engineering Ltd., Olds). 1987. Drainage Potential in Alberta: An Integrated Study. Technical Report 1: Drainage Engineering Component. Alberta Environment, Alberta Agriculture and Alberta Forestry, Lands and Wildlife. 131 p., 24 tables, 38 Figures, 42 references.

* Leskiw, L.A. (Pedology Consultants, Edmonton). 1987. Drainage Potential in Alberta: An Integrated Study. Technical Report 3: Soils and Agronomy Component. Alberta Environment, Alberta Agriculture and Alberta Forestry, Lands and Wildlife.. 103 p., 33 tables, 17 figures, 5 appendices, 42 references.

* W-E-R Engineering Ltd. in association with JNMackenzie Engineering Ltd. (Calgary) 1987. Drainage Potential in Alberta: An Integrated Study. Technical Report 2: Hydrology/Hydraulics Component. Alberta Environment, Alberta Agriculture and Alberta Forestry, Lands and Wildlife.. 106 p., 29 tables, 8 figures, 9 plates, 59 references. Includes appendices on the effect of participation rate and controlled versus uncontrolled drainage.

W-E-R Engineering Ltd. in association with JNMackenzie Engineering Ltd. 1986. Hydrology and Hydraulics Methods Report. Prepared for the Interdepartmental Steering Committee on Drainage. Calgary, W-E-R Engineering Ltd.

A.3 Government Advisors

Jim Barlishen, Economist, Planning Services Branch, Planning Division, Alberta Environment.
Franklin Davies, Hydrologist, Hydrology Branch, Technical Services Division, Alberta Environment, Edmonton.
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David Hervieux, Wildlife Biologist, Habitat Branch, Fish and Wildlife Division, Alberta Forestry, Edmonton.
Kathleen MacDonald-Date, Supervisor Resource Economist, Production and Resource Economic Branch, Alberta Agriculture, Edmonton.
Carlos Parraguez, Economist, Planning Services Branch, Planning Division, Alberta Environment, Edmonton.

Maps produced by Cartographic Services Section, Resource Evaluation Branch, Alberta Forestry. Cover designed by Print Media Branch, Information Services Division, Alberta Agriculture.

APPENDIX B

PHASE I SUPPORTING INFORMATION

Table B.1
PHASE I STUDY AREAS

STUDY AREA NAME Location & General Description	WETLAND CHARACTERISTICS
LA CRETE, northern Alberta (Twp. 106 - Rges. 13,14 - W 5th) Topography: level to undulating Materials: lacustrine (lake sediments) Soil types: luvisols Agriculture: land clearing extensive; crops: barley, wheat, canola	- located in the Peace River Basin - few distinct channels - most wetlands are bogs - cultivated areas are former bogs - there may be some ponding in the summer, but generally cultivated areas are only slightly affected by excess moisture - moisture collects in bogs and temporary sloughs

LA CRETE is considered representative of the northern part of Alberta undergoing agricultural expansion into areas dominated by bogs and fens.

STUDY AREA NAME Location & General Description	WETLAND CHARACTERISTICS
FALHER, northwestern Alberta (Twp. 77 - Rges. 21,22 - W 5th) Topography: level to undulating Materials: fine-textured lacustrine Soil types: Solonetzic Agriculture: most of the area in production of cereals, forages & oilseeds	- located in the Smoky River Basin (Peace River Basin) - few natural watercourses - during wet periods, large areas flooded because of flat topography and fine textured soils - temporary ponding (sheetwater) due to heavy rains - eastern area has temporary slough/marshes - western half of 77-22-W5 has small isolated sloughs

FALHER generally represents level and fine textured plains in Alberta, most notably those of the Peace River region.

STUDY AREA NAME Location & General Description	WETLAND CHARACTERISTICS
GRANDE PRAIRIE, northwestern Alberta (Twps. 72,73 - Rge. 3 - W 6th) Topography: Material: glacial till in east, lacustrine in west Soil types: Chernozemic & Solontezic Agriculture: most land in cereal crops, with some hay and pasture - few uncleared tracts of land	- located in the Smoky River Basin (Peace River Basin) - sheetwater occurs in western part of area due to level topography and slow infiltration rates of fine-textured materials and solonetzic soils - in the morainal areas, temporary and permanent slougn/marsh, bog/fen and lake/pond - there are many small isolated or overflow sloughs in the eastern half

GRANDE PRAIRIE demonstrates the variability of wetland permanency found in hummocky till areas, such as the Clear Hills area in the Peace River region.

Table B.1
PHASE I STUDY AREAS (continued)

STUDY AREA NAME **Location & General Description**	**WETLAND CHARACTERISTICS**
ATHABASCA, east central Alberta (Twp. 66 - Rges. 20,21 - W 4th)	- located in the Athabasca River Basin
Topography: undulating Materials: till and lacustrine Soils: Organic in 66-21, Luvisols on morainal and fluvial ridges in 66-20 Agriculture: well drained areas used for cereal and forage, imperfectly drained areas used for hay and pasture	- a large portion undeveloped for agriculture because of extensive bogs and associated poor drainage - many of the bogs are channel or basin bogs, up to 24 km long and 3 km wide - in the upland areas there are overflow or isolated bogs, but most have been drained

ATHABASCA represents the large areas with a predominance of bogs and fens located on the fringe of an agricultural area.

MUNDARE, east central Alberta (Twp. 54 - Rges. 15,16 - W 4th)	- located in the North Saskatchewan River Basin
Topography: undulating and level Materials: till Soils: Black Chernozems in west and south, Solonetzic soils in north and east Agriculture: basically agricultural area, with a mixture of cereal and forage crops	- many drained wetlands; cultivated sloughs, often small - permanent and non-permanent slough/marshes - some salinity encountered in range 15 and central part of 16 - there is some pasture

MUNDARE represents the parkland and solonetzic soils area of east-central Alberta.

YOUNGSTOWN, southeastern Alberta (Twps. 28,29 - Rge. 9 - W 4th)	- located in the Red Deer River & Sounding Creek Basins
Topography: undulating to gently rolling Materials: morainal, except for north, with fluvial (sandy loam/loamy sand) Soils: Brown Solonetzic soils - one-third of the area cultivated with wheat as the major crop, the rest in native rangeland	- numerous large areas of saline soil and semi-permanent lakes in east side of twp. 29 - temporary slough/marsh in morainal areas - many temporary watercourses present in south

YOUNGSTOWN has a wetland distribution typical of those in solonetzic soil areas of the semi-arid prairie zone. These are conditions typical of Alberta's Special Areas.

Table B.1
PHASE I STUDY AREAS (continued)

STUDY AREA NAME **Location & General Description**	**WETLAND CHARACTERISTICS**
LETHBRIDGE, southern Alberta (Twps. 10,11 - Rge. 23 - W 4th)	- located in the Oldman River Basin
Materials: lacustrine over glacial till Soils: Chernozems Agriculture: about 1/3 of area irrigated - the rest is in dryland farming: spring and winter wheat	- slough/marshes of varying degress of permanency - seepage areas (usually saline)

LETHBRIDGE has seepage areas and other wetland types on both dryland and irrigated farming areas, typical of many agricultural areas of southern Alberta.

TABLE B.2 INITIAL CLASSIFICATION SYSTEM USED FOR WETLANDS INVENTORY OF ALBERTA - PHASE I*

TYPE	PERMANENCY	VEGETATION	WATERSHED POSITION	CHEMISTRY	DISTURBANCES
P Slough/Marsh	n Not Determined	0 None	.N Not applicable	n Not applicable	U Undisturbed
S Seep	e Ephemeral	1 Herbaceous	.I Isolated	s saline	N Natural
B Bog/Fen	t Temporary	2 Shrub	.O Overflow	k alkaline	D Drainage
L Lake/Pond	s Seasonal	3 Tree-hardwood	.C Channel	a acidic	I Irrigation
H Sheetwater	m Semi-permanent	4 Tree-coniferous	.T Terminal	d sodic	T Tillage/grazing/ mowing
W Watercourse	p Permanent	5 Aquatic			M Impoundment
		6 Cultivated crop			R Resource Extraction
		7 Improved pasture/forage			C Cleared/regrowth
N Non-arable					L Linear
					O Other

EXAMPLE Pt1.TnD

P= slough/marsh
t= temporary
1= herbaceous cover
.T= terminal location
n= no chemistry evident
D= drainage works present

* SOURCE: Intera Technologies Ltd., Jensen Engineerng Ltd., and Western Soils Consulting Ltd. Sept. 1984. Alberta Agricultural Wetlands Drainage Inventory: Phase 1 Aerial Photography Analysis and Ground Surveys. Volume 1 Final Report. Calgary. p. 32

Table B.2 (continued)

WETLAND CLASSIFICATION SYSTEM USED FOR PHASE I STUDIES
Definition of Wetland Classes

(SOURCE: Intera Technologies Ltd. 1984a, p.114-118)

WETLAND: Land having water at, near or above the land surface or which is saturated for a long enough period to promote wetland or aquatic processes.

1. WETLAND TYPE

P SLOUGH/MARSH	Enclosed or peripheral wetland occurring in natural undrained or drained basins and low-lying areas, mainly in the prairie/parkland region, frequently bordering open water. Periodic inundation results in seasonally fluctuating surface water levels. All levels of permanency encountered. Mineral-rich waters support growth of reeds (*Phragmites* spp.), rushes (*Juncus* spp.), sedges and hydrophyllic grasses. Peripheral rings of shrubs and trees may be present.
S SEEP	Wet areas due to seepage from groundwater in dryland areas, or canal/ditch and/or groundwater in irrigated areas. They are seasonal or better in permanency, and are frequently saline with associated halophytic vegetation.
B BOG/FEN	Peat- or sedge-covered (filled) wetland generally with a high water table. Usually of permanent or semi-permanent nature, but may become seasonal after clearing and cultivation. Surface water in bogs is acidic (strong to medium); sphagnum, feathermoss and ericaceous shrubs, sometimes with black spruce and/or tamarack (*Larix laricina*). Surface water in fens is less acid (neutral to medium) and minerotrophic; vegetation cover includes sedges, reeds, brown mosses (*Drepanocladus* spp.) and minor shrubs. Soils are organic order or peaty phase Rego Humic Gleysols.
L LAKE/POND	Permanent open body of water, sometimes semi-permanent in nature. Lacks continuous directional flow, although there may be inflow and outflow. Submerged aquatic vegetation may be present and littoral zones or other wetland types may ring the lake/pond. Lake/pond shore is minerotrophic (as opposed to the organic materials around open water in bog/fen).

H SHEETWATER	Intermittent shallow open water area, periodically inundated by surface waters that persist for short periods before being lost through surface drainage, evaporation or infiltration. Recognized in cultivated areas where seeding was delayed due to ponded water, or where the crop has been moisture-stressed after heavy summer rains. Usually ephemeral. May take the form of shallow channelized depressions or nearly level basins, or be found in floodplains.
W WATERCOURSE	Channelized flow of running water, usually with wetland borders of riparian trees, shrubs and/or herbaceous vegetation. Channel shown as line on base map, with associated wetland area mapped as polygon. May have any level of permanency.
N NON-ARABLE	Land not classed as wetland, is very obviously non-arable and not currently cultivated due to problems with slope (e.g. greater than 30%) or conflicting existing land (e.g. urban area, gravel pit). No descriptive modifiers.

2. WETLAND PERMANENCY

n NOT DETERMINED	Permanency of the wetland cannot be determined.
e EPHEMERAL	Contains surface water only during and after a rain or snowmelt. Rapid bottom infiltration outflow. Low prairie zone dominant in native conditions, but also frequent in cultivated land.
t TEMPORARY	Fairly rapid bottom infiltration outflow. Surface water present for only a few weeks after spring snowmelt and for several days after heavy rain. Wet-meadow zone dominant. Farmers may get stuck during spring seeding.
s SEASONAL	Surface water maintained for extended period in spring and early summer, usually dry in late summer and fall. Shallow-marsh zone dominant. Shrubs and hardwood trees may also be present around bogs and fens. Peripheral wet-meadow or tillage zone usually present.
m SEMI-PERMANENT	Surface water maintained throughout spring and summer and frequently into fall and winter. Usually a marginal band of hydrophyllic vegetation around permanent open water. Deep-marsh zone dominant. Shrubs and hardwood trees may also be present around the wetland. Peripheral shallow-marsh zone and wet-meadow or tillage zone usually

	present and occasionally isolated pockets of alkaline bog zone occur. Often water 5-8 years out of 10.
p PERMANENT	Surface water in Lake/Pond and Watercourse is present year-round, fed by stable groundwater flow. Bogs/Fens are usually considered permanent, although the open surface water is frequently covered by peat, sedges, and taller vegetation (shrubs, trees).

3. WETLAND VEGETATION

O NONE	No vegetation present. May be either barren soil or rock, or deep open water.
1 HERBACEOUS	Herbaceous native vegetation dominant. Grass, forb, reed, sedge, moss, lichen.
2. SHRUB	Shrub vegetation dominant. Usually willow (*Salix* spp.), alder (*Alnus* spp.), swamp birch (*Betula pumila*, *B. glandulosa*).
3. TREE - HARDWOOD	Broad-leaved tree cover dominant. Usually balsam poplar (*Populus balsamifera*), paper birch (*Betula papyrifera*), trembling aspen in the north, and willow (*Salix* spp.) and several poplar species in the south.
4. TREE - CONIFEROUS	Coniferous tree cover dominant. Usually black spruce (*Picea mariana*) and tamarack (*Larix laricina*) with some white spruce (*Picea glauca*) and jack pine (*Pinus banksiana*).
5. AQUATIC	Emergent or aquatic macrophyte vegetation present. May include bulrushes (*Scirpus* spp.), reeds (*Phragmites* spp.), rushes (*Juncus* spp.), cattails (*Typha latifolia*), pondweed (*Potamogeton* spp.), milfoil (*Myriophyllum* spp.), pond lily (*Nuphar* spp.).
6. CULTIVATED CROP	Cultivated crop cover dominant where wetland disturbed by tillage. Includes summerfallow.
7. IMPROVED PASTURE/ FORAGE	Land improved through clearing and breaking and seeded to perennial forage and pasture crops.

4. WATERSHED POSITION

.N NOT APPLICABLE	Position in watershed does not apply or cannot be determined.

.I ISOLATED	Receives runoff waters only from surrounding upland, never overflows. Usually temporary or ephemeral.
.O OVERFLOW	Receives runoff water from surrounding upland, but depression depth is limited. Will overflow when it receives sufficient water. Characteristic of topographically high areas. Overflow usually temporary.
.C CHANNEL	Receives runoff from surrounding uplands and from Overflow or Channel wetlands higher in the watershed; will overflow when full. Occurs in variety of topographic situations (e.g. upland sites, glacial meltwater channels). Moisture regime highly variable.
.T TERMINAL	Receives runoff from surrounding uplands and from Overflow or Channel wetlands. Cannot overflow themselves. Found in topographically low areas and represents endpoint of internal drainage systems. Highly variable moisture regime; water loss is by evaporation and infiltration.

5. CHEMISTRY

n NOT APPLICABLE	Chemical status not applicable (e.g. not detrimental to cultivated crops) or cannot be determined. Usually medium acid to slightly alkaline and non-saline.
s SALINE	Salt deposition is indicated either by presence of white encrustation or of salt-tolerant plant species (e.g. summer cypress (Kochia scoparia), foxtail barley (Hordeum jubatum), samphire (Salicornia rubra), wheatgrass (Agropyron spp.). Usually found in seepage areas, discharge sloughs and evaporation basins.
k ALKALINE	Alkaline or neutral water is evidenced by alkali-tolerant plant species.
a ACIDIC	Acidic water or organic soil inferred from plant species present (e.g. black spruce (Picea mariana), sphagnum, feathermoss).
d SODIC	Evidenced by low-lying, bare soil areas. Dispersed soil surface and crusting due to high levels of absorbed sodium. Found in some evaporation basins and terminal position lakes.

6. DISTURBANCE

U	UNDISTURBED	Appears undisturbed (in natural condition).
N	NATURAL	Natural event (beaver activity, erosion, slumping) has caused inundation and/or ponding.
D	DRAINAGE	Subjected to man-made surface of sub-surface drainage works, to remove water from wetland.
I	IRRIGATION	Disturbed by irrigation-related activity (flooding, seepage).
T	TILLAGE/GRAZING/ MOWING	Disturbed by tillage or mowing of hay, or livestock grazing.
C	CLEARED	Area cleared but not currently in agricultural land use. Often shrubs (e.g. willow) have re-established.
M	IMPOUNDMENT	Man-made impoundment of surface water (reservoir, dugout).
R	RESOURCE EXTRACTION	Disturbed by natural resources extraction activities (gravel pit, borrow pits, forestry, mining).
L	LINEAR	Disturbed by linear construction activities (roads, pipelines, seismic lines, railways etc.) causing change in permanency and area of wetland.
O	OTHER	Wetland disturbed by undetermined activity or type other than listed above.

Table B.3

AERIAL PHOTOGRAPHS USED FOR INTERPRETATION OF WETLANDS - PHASE I

STUDY AREA	COLOUR PHOTOGRAPHS 1:40,000 SCALE		CIR PHOTOGRAPHS 1:40,000 SCALE		EXISTING GOVERNMENT PHOTOS (black & white except for *)		
	Date	Quality	Date	Quality	Date	Scale	Moisture Conditions
1. La Crete	28 Sept. 1983	Good	25 Sept. 1983	Good			
2. Grande Prairie	23 Sept. 1983	Some cloud cover & shadowing	5 Nov. 1983 (reflown)	Fair (dark)			
3. Falher	22 & 23 Sept. 1983	Good	22 & 23 Sept. 1983	Good	22 June 1967 Sept. 1973	1:31,680 1:31,680	Dry Wet
4. Athabasca	25 Sept. 1983	Good	5 Nov. 1983 (reflown)	Fair (dark)			
5. Mundare	25 Sept. 1983	Good	25 Sept. 1983	Some frames overexposed	22 July 1967	1:31,680 1:31,680	Dry Wet
6. Youngstown	25 Sept. 1983	Good	25 Sept. 1983	Some frames overexposed			
7. Lethbridge	25 Sept. 1983	Good	25 Sept. 1983	Generally overexposed	3 May 1970 May 1978* (colour)	1:31,680 1:10,000	Dry Wet

SOURCE: Intera (1983b), p. 24.

Table B.4
LANDSAT DATA FOR SEVEN STUDY AREAS

STUDY AREA	Use	Date	Quality
1. La Crete	Dry	14/08/81	
	Fall 83	20/09/83	
	Summer 83	10/8/83	
2. Grande Prairie	Wet	13/07/82	
	Dry	14/08/81	Cloud,haze
	Fall 83	27/09/83	
	Summer 83	10/8/83	
3. Falher	Summer 83	10/8/83	
4. Athabasca	Fall 83	22/09/83	
5. Mundare	Wet	19/07/73	
	Dry	9/8/81	Cloud, shadow
	Fall 83	20/08/83	
6. Youngstown	Fall 83	1/9/83	
7. Lethbridge	Wet	11/8/77	
	Dry	19/07/73	Only part of area
	Fall 83	24/09/83	

SOURCE: Intera (1983b), p. 31.

APPENDIX C

PHASE II SUPPORTING INFORMATION

TABLES

FIGURES

Table C.1

REVISED CLASSIFICATION SYSTEM USED FOR WETLANDS INVENTORY OF ALBERTA - PHASE II*

TYPE	PERMANENCY	WETLAND GROUND COVER	UPLAND GROUND COVER	WATERSHED POSITION	FORM	DISTURBANCE	CHEMISTRY	COMPLEX
P Slough/Marsh	t Temporary	0 Bare soil/rock	0 Bare soil/rock	.I Isolated	d deep depression	U Undisturbed	s saline	1 20 - 50 %
S Seep	s Seasonal	1 Herbaceous	1 Herbaceous	.O Overflow	h shallow depression	D Drainage	n non-saline	2 50 - 80 %
B Bog/Fen	p Permanent	2 Shrub	2 Shrub	.C Channel	c channel	I Irrigation		
L Lake/Pond		3 Tree-hardwood	3 Tree-hardwood	.T Terminal	b basin	M Impoundment		
H Sheetwater		4 Tree-coniferous	4 Tree-coniferous		s sloping	T Tillage/grazing/ mowing		
W Watercourse		5 Aquatic	5 Herbaceous-shrub			R Resource Extraction		
		6 Cultivated crop	6 Herbaceous-tree			C Cleared/regrowth		
		7 Improved pasture/forage	7 Shrub/tree			O Other		
		8 Open Water	8 Cultivated crop/ summerfallow					
			9 Improved pasture/forage					
			N Not applicable					
N Non-arable								

EXAMPLE

Pt1. OhDS2

P= slough/marsh
t= temporary
1= herbaceous cover
.O= overflow position
h= shallow depression form
D= drainage works present
saline
2= 65% of area outlined

Lp8.TbM

L= lake/pond
p= permanent
8= open water
.T= terminal position
b= basin form
M= impoundment

The last two spaces are default positions for "non-saline" chemistry and 80 - 100 % of the outlined area as wetland.

All terms are defined in Appendix C.

* SOURCE: Intera Technologies Ltd. (1985), p.9.

Table C.1 (continued)

WETLAND CLASSIFICATION SYSTEM USED FOR PHASE II STUDIES
Definition of Wetland Classes

(SOURCE: Intera Technologies Ltd. 1985: 47-57)

1. WETLAND TYPE

The wetland type is the primary inventory classifier, indicating the dominant characteristics of the map unit and implying to some extent, the range in permanency as well as the vegetation component. Six wetland types, plus a non-arable, non-wetland class are used.

"Non-arable" (non-wetland) land (N) is included in the mapping to indicate the amount of land within each study area which is "very obviously" non-arable and therefore not classed within the agricultural land base (e.g. urban area, gravel pit, very steep slope).

P	SLOUGH/MARSH	**Enclosed or peripheral wetland occurring in a depression where surface drainage is obstructed causing water to accumulate.** Periodic inundation results in seasonally fluctuating surface water levels. All levels of permanency encountered. Mineral-rich waters support growth of aquatic or hydrophyllic vegetation. Peripheral rings of shrubs and trees may be present. Open water occupies less than 50% of the wetland.
S	SEEP	**Wet areas from groundwater discharge at the soil surface.** Typically found on side slopes adjacent to canals and ditches, and in low-lying areas, often associated with either dryland or irrigation agriculture. Also associated with hummocky or rolling terrain. Seasonal or permanent. Frequently saline with associated halophytes.
B	BOG/FEN	**Peat- or sedge-filled wetland.** Usually permanent; may become seasonal after clearing and cultivation and in this case is evidenced by dark soil surface, apparent depressional area and often has adjacent uncleared bogs. Surface water in bogs is acidic (strong to medium); mosses, ericaceous shrubs, and often coniferous trees present. Surface water in fens is less acid (neutral to medium) and minerotrophic; vegetation cover includes sedges, reeds, grasses and minor shrubs. Soils are organic order or peaty phase Rego Humic Gleysols.
L	LAKE/POND	**Permanent open body of water.** Lacks continuous directional flow, although there may be inflow and outflow. Submerged aquatic vegetation may be present; littoral zones or other wetland types may

ring the lake/pond but occupy less than 50% of the (polygon) wetland area.

H SHEETWATER

Area of relatively flat terrain, not occurring in a distinct depression, which is periodically inundated by surface waters that persist for short periods (before being lost through surface drainage, evaporation or infiltration). In cultivated areas, where seeding delayed due to ponded water, or crop moisture-stressed after heavy summer rains. Temporary. May be dissected by shallow, channelized depressions and may occur due to temporary flooding from adjacent watercourses.

W WATERCOURSE/ FLOOD PLAIN

Channelized flow of running water produces adjacent wetland of riparian trees, shrubs and/or herbaceous vegetation. Channel shown as line on base map, with associated riparian area mapped as polygon. May have any level of permanency. Permanency is established by evaluating the floodplain characteristics and is not necessarily a reflection of water levels in the stream channel proper.

N NON-ARABLE

Land not classed as wetland, is very obviously non-arable and not currently cultivated due to problems with slope (e.g. greater than 30%) or conflicting existing land (e.g. urban area, gravel pit). No descriptive modifiers.

2. WETLAND PERMANENCY

The second classifier (Permanency) uses three classes modified from Millar (1976) (temporary, seasonal and permanent), since all five Millar classes cannot be identified accurately on the 1:50,000 scale photography. Millar's "ephemeral" and "temporary" have been combined as "temporary", and "seasonal" and "semi-permanent" combined as "seasonal" for the mapping. These classes were well defined for prairie/parkland wetlands, but have been modified for application to the permanency of wetlands in the parkland/boreal zones.

t TEMPORARY

Surface water present for only a few weeks after spring snow melt and/or for several days after heavy rain. Low prairie or wet-meadow zone dominant. Farmers may get stuck during spring seeding. Shallow depressions often cultivated, particularly in southern Alberta.

s SEASONAL

Surface water maintained for extended periods in spring and early summer, usually dry in late summer and fall. Shallow-marsh zone dominant. Shrubs and trees may also be present around the

	wetland. Peripheral wet-meadow or tillage zone may be present.
p PERMANENT	**Wetland conditions present year-round.** Open water of deep marsh zone dominant; emergent and open water phases in particular (e.g. aquatic vegetation or moss or sedge peats for bog/fens). Commonly deep depressions for slough/marsh.

3. WETLAND GROUND COVER

The ground cover of a wetland is an important indicator of wetland type, permanency, climatic region, level of disturbance and chemistry, and varies widely in accordance with these parameters. The nine vegetation classes include bare soil/rock, herbaceous, shrub, hardwood trees, coniferous trees, aquatic vegetation, cultivated crops, improved pasture/forage and open water.

O BARE SOIL/ROCK	**No vegetation present.** Barren soil or rock.
1 HERBACEOUS	**Herbaceous native vegetation dominant.** Grass, forb, reed, sedge, moss.
2. SHRUB	**Shrub vegetation dominant.** Usually willow (Salix spp.), alder (Alnus spp.), swamp birch (Betula pumila, B. glandulosa).
3. TREE - HARDWOOD	**Broad-leaved tree cover dominant.** Usually balsam poplar (Populus balsamifera), paper birch (Betula papyrifera), trembling aspen in the north, and willow (Salix spp.) and several poplar species in the south.
4. TREE - CONIFEROUS	Needle-leaved tree cover dominant. Usually black spruce (Picea mariana), tamarack (Larix laricina), some white spruce (Picea glauca) and jack pine (Pinus banksiana).
5. AQUATIC	**Emergent or aquatic macrophyte vegetation present.** May include bulrushes (Scirpus spp.), reeds (Phragmites spp.), rushes (Juncus spp.), cattails (Typha latifolia), pondweed (Potamogeton spp.), milfoil (Myriophyllum spp.), pond lily (Nuphar spp.).
6. CULTIVATED/CROP SUMMERFALLOW	**Cultivated crop cover or summerfallow dominant.** Wetland disturbed by tillage.
7. IMPROVED PASTURE/ FORAGE	**Land seeded to perennial forage crops.**
8. OPEN WATER	**Open water dominant** (little or no aquatic vegetation, mud flats, etc. present).

4. UPLAND GROUND COVER

The ground cover of the upland areas adjacent to the mapped wetlands is important for wildlife habitat evaluation. This classifier provides a subjective assessment of the dominant upland vegetation immediately adjacent to the outer wetland perimeter, thus providing an additional indicator of the importance of each wetland as wildlife/waterfowl habitat. Eleven classes are used, including the grass/shrub/tree combined classes which are important for habitat evaluation. Where the wetland is mapped within another wetland polygon (and thus not adjacent to upland cover), then the "not applicable" class is used.

0	BARE SOIL/ROCK	**No vegetation present.** Barren soil of rock.
1	HERBACEOUS	**Herbaceous native vegetation dominant.** Grass, sedge, forb.
2.	SHRUB	**Shrub vegetation dominant.** Usually willow (Salix spp.), green alder (Alnus crispa), rose (Rosa spp.), snowberry (Symphoricarpos spp.) and other upland shrubs.
3.	TREE - HARDWOOD	**Broad-leaved tree cover dominant.** Usually balsam poplar (Populus balsamifera) and trembling aspen in the north, and willow (Salix spp.) and aspen in the south.
4.	TREE - CONIFEROUS	**Needle-leaved tree cover dominant.** Usually white spruce (Picea glauca), lodgepole pine (Pinus contorta var. latifolia), jack pine (Pinus banksiana), and/or fir (Abies spp.) present.
5.	HERBACEOUS/SHRUB	**Mixture of upland open herbaceous and shrub vegetation** as defined above. Greater than 30% of each category. If one has less than 30% then identify only by dominant category (i.e. either herbaceous or shrub).
6.	HERBACEOUS/TREE	**Mixture of upland open herbaceous and tree vegetation** as defined above. Greater than 30% of each category.
7.	SHRUB/TREE	**Mixture of upland shrub and tree vegetation** as defined above. Greater than 30% of each category.
8.	CULTIVATED/CROP SUMMERFALLOW	**Cultivated crop cover or summerfallow dominant.**
9.	IMPROVED PASTURE/ FORAGE	**Land seeded to perennial forage crops.**
N	NOT APPLICABLE	**Wetland is surrounded by another wetland polygon.**

5. WATERSHED POSITION

The four watershed position classifiers, taken directly from Millar (1976) were included because of the relationship of the watershed position to the spring runoff and thus water regime of the wetland. This refers to the topographic/hydrologic position of the wetland in the landscape.

.I ISOLATED	**Receives runoff waters only from surrounding upland, never overflows.** Usually temporary.
.O OVERFLOW	**Receives runoff water from surrounding upland, but depression depth is limited and will overflow when it receives sufficient water.** Characteristic of topographically high areas. Overflow usually temporary.
.C CHANNEL	**Receives runoff from surrounding uplands and from Overflow or Channel wetlands higher in the watershed; will overflow when full.** Wetland occurs within the depressional, open-ended active fluvial or glacial meltwater channel and may occupy either the entire channel (in which case the wetland form would also be "channel") or a portion thereof (e.g. a shallow slough occurring in a meltwater channel would have a shallow depression form).
.T TERMINAL	**Receives runoff from surrounding uplands and from Overflow or Channel wetlands.** Cannot overflow itself. Found in topographically low areas and represents endpoint of internal drainage system. Highly variable moisture regime.

6. FORM

In addition to its position in the watershed, the physical characteristics (primarily size, shape and depth) of the wetland (form) are significant for identifying drainage potential. Five classes have been included, covering the depressional, channel, basin and sloping wetland forms.

d DEEP DEPRESSION	**Sharply defined depression.** Isolated or overflow watershed position. Commonly found in hummocky topography (e.g. kettle, bowl). Dugouts are also generally of this form.
h SHALLOW DEPRESSION	**Shallow depressional area with a diffuse or poorly-defined boundary.**
c CHANNEL	**Depressional open-ended form with defined sides.** Open-ended eroded channels. Abandoned glacial meltwater spillways, intermittent drainage courses.

b BASIN — **Extensive depressional (concave) area.** Isolated, overflow or terminal position. Predominantly associated with Bog/Fen, Lake/Pond or Sheetwater wetland types.

s SLOPING — **Inclined surface with slope greater than 2%.** Usually associated with Seeps and areas where downslope runoff is restricted.

7. DISTURBANCE

The type of disturbance (or nature of land use) to which each wetland has been subjected by natural or anthropogenic activities is an important factor in assessing potential for drainability (e.g. a wetland which has already been extensively disturbed by cultivation may be a better candidate for drainage than one which is in pristine condition providing food and habitat for waterfowl). Nine classes indicate the type of disturbance (undisturbed, drainage, irrigation, grazing, tillage, cleared, impoundment, resource extraction and other).

U UNDISTURBED — **Appears undisturbed.** In natural condition.

D DRAINAGE — **Disturbed by man-made surface of sub-surface drainage works** (to remove water from wetland).

I IRRIGATION — **Disturbed by irrigation-related activity** (flooding, seepage).

G GRAZING — **Grazing disturbance by domestic livestock.**

T TILLAGE — **Disturbed by tillage or mowing of forage.**

C CLEARED — **Cleared of trees and/or shrubs, but not presently in crop production.** Often shrubs (e.g. willow) have re-established.

M IMPOUNDMENT — **Man-made excavation or dam retains surface water** (reservoir, dugout).

R RESOURCE EXTRACTION — **Disturbed during recovery of natural resources** (gravel pit, borrow pits, forestry, mining).

O OTHER — **Wetland disturbed by undetermined activity or type other than listed above. Includes beaver activity.**

8. CHEMISTRY

Chemistry within a wetland is considered important for a variety of reasons related to waterfowl habitat, agricultural potential, groundwater influence, etc. Saline conditions were considered to be the most significant for an Alberta wetland inventory.

NON-LIMITING (default)	**Chemical status not limiting to crop production.** Non-saline (may be acid, neutral or alkaline).
s SALINE	**Soil salinity limiting to crop production or vegetative growth.** Salt deposition is indicated either by presence of white encrustation or of salt-tolerant plant species (e.g. summer cypress (Kochia scoparia), foxtail barley (Hordeum jubatum), samphire (Salicornia rubra), western wheatgrass (Agropyron smithii). Usually found in seepage areas, discharge sloughs and evaporation basins.

9. COMPLEX

The "Complex" class provides a means of mapping complexes of wetlands and uplands. This permits very small, yet identifiable wetlands to be mapped as a complex rather than individually or having to be omitted. Areas where wetlands occupy over 80% of the surface area are mapped as a single unit (not a complex), and areas where wetlands occupy less than 20% are not mapped as wetlands. Two classes (20-50% and 52-80%) subdivide the middle range. The mid-point of each (35% and 65% respectively) will be used for the calculation of wetland area in the digitizing process.

(default)	**Wetland occupies 80-100% of the area.**
1	**Wetlands occupy 20 to 50%** (mid-class 35%) of delimited area, with the remainder of area upland.
2	**Wetlands occupy 52 to 80%** (mid-class 65%) of delimited area, with the remainder of area upland.

Table C.2
EXAMPLE OF WETLAND DATA TABULATION FOR ONE TOWNSHIP

NOTES Data are for Township 84, Range 12, West of the 6th Meridian.

Numbers across the top are section numbers.

Abbreviations:	t - temporary	< 5 - Less than 5 acres
	s - seasonal	5-15 - 5 to 15 acres is size
	p - permanent	> 15 - Larger than 15 acres

SOURCE: Harrison 1986. Data Appendices.

84126 WETLANDS TOWNSHIP AREA ACCUMULATION page 1

12 6 85

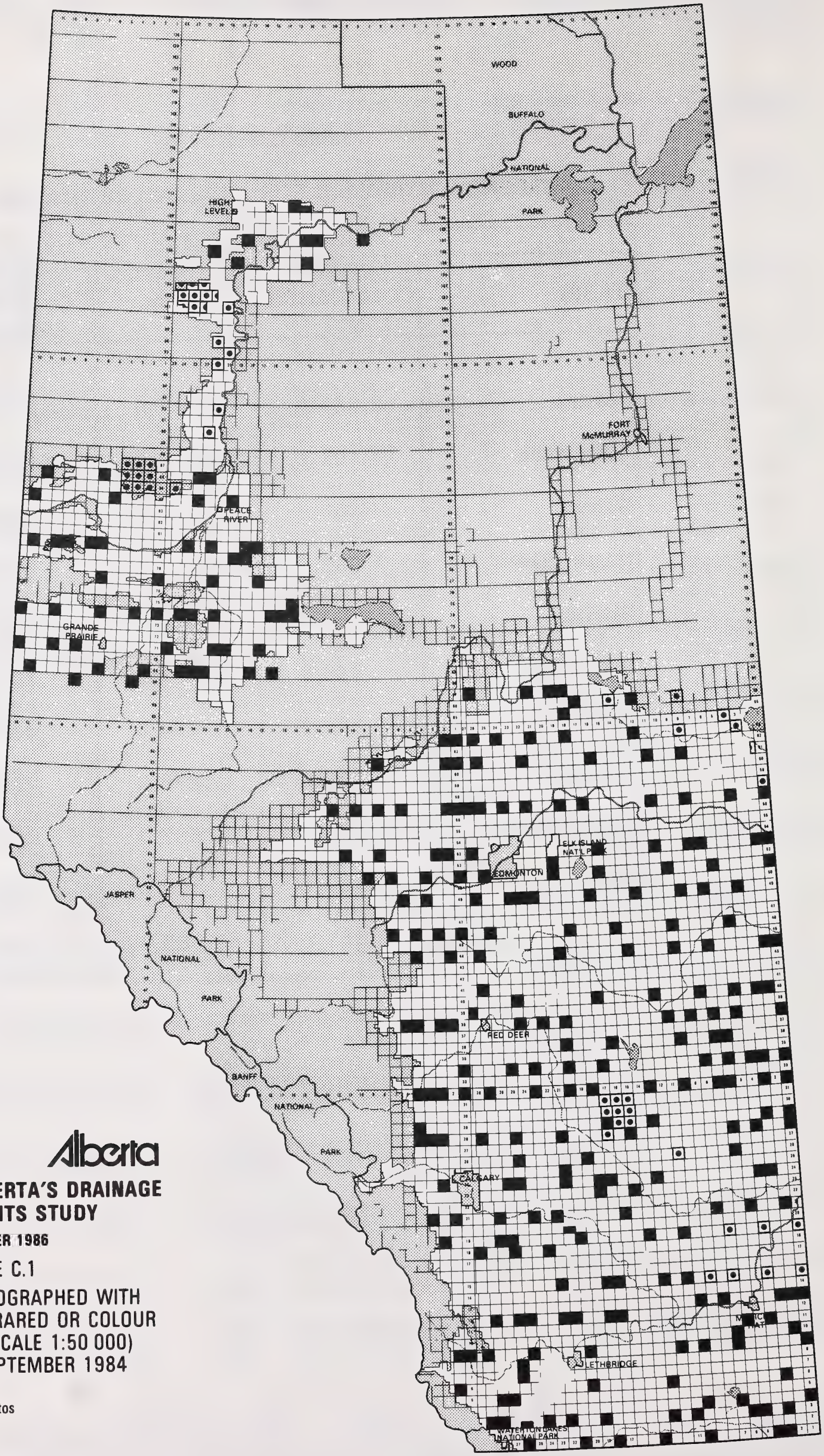
	1	4	5	8	9	12	13	16	17	20	21	24	26	28	29	32	33	36	TOTAL	MEAN	VARIANCE
SLOUGH/MARSH																					
t < 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
t 5-15	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.6	5.556
t > 15	21.4	0.0	0.0	0.0	0.0	0.0	174.0	0.0	0.0	0.0	0.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	213.4	11.9	1678.117
t sub-tot	31.4	0.0	0.0	0.0	0.0	0.0	174.0	0.0	0.0	0.0	0.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	223.4	12.4	1694.901
s < 5	0.0	0.0	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1	0.3	2.067
s 5-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9	0.0	0.0	0.0	0.0	0.0	8.9	0.5	4.401
s > 15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
s sub-tot	0.0	0.0	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9	0.0	0.0	0.0	0.0	0.0	15.0	0.8	6.113
temp-tot	31.4	0.0	6.1	0.0	0.0	0.0	174.0	0.0	0.0	0.0	0.0	18.0	8.9	0.0	0.0	0.0	0.0	0.0	238.4	13.2	1679.112
p < 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
p 5-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
p > 15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
perm-tot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
gnd total	31.4	0.0	6.1	0.0	0.0	0.0	174.0	0.0	0.0	0.0	0.0	18.0	8.9	0.0	0.0	0.0	0.0	0.0	238.4	13.2	1679.112
SEEP																			TOTAL	MEAN	VARIANCE
t < 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
t 5-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
t > 15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
t sub-tot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
s < 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
s 5-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
s > 15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
s sub-tot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
temp-tot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
p < 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
p 5-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
p > 15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
perm-tot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
gnd total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
BOG/FEN																			TOTAL	MEAN	VARIANCE
t < 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
t 5-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
t > 15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
t sub-tot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
s < 5	0.0	0.0	4.6	0.0	2.3	0.0	0.0	2.8	8.1	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.7	1.2	4.971
s 5-15	0.0	13.8	0.0	18.5	0.0	0.0	0.0	11.2	15.1	5.3	10.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	74.4	4.1	42.174
s > 15	0.0	0.0	16.0	0.0	0.0	0.0	0.0	0.0	87.7	0.0	0.0	0.0	0.0	52.2	0.0	0.0	0.0	0.0	155.9	8.7	548.345
s sub-tot	0.0	13.8	20.6	18.5	2.3	0.0	0.0	14.0	110.9	8.2	10.5	0.0	0.0	52.2	0.0	0.0	0.0	0.0	251.0	13.9	756.437
temp-tot	0.0	13.8	20.6	18.5	2.3	0.0	0.0	14.0	110.9	8.2	10.5	0.0	0.0	52.2	0.0	0.0	0.0	0.0	251.0	13.9	756.437
p < 5	0.0	0.0	4.4	0.0	0.0	0.0	0.0	4.8	4.0	20.9	1.0	0.0	2.4	8.1	2.5	2.3	3.8	0.0	54.2	3.0	25.315
p 5-15	0.0	0.0	23.2	0.0	10.2	0.0	0.0	28.5	61.9	40.2	23.3	0.0	0.0	20.8	22.9	0.0	0.0	14.7	253.7	14.1	330.215
p > 15	0.0	42.6	18.9	26.9	17.8	0.0	0.0	65.6	53.8	15.4	157.0	0.0	0.0	160.0	247.0	407.0	186.0	0.0	1398.0	77.7	12563.081
perm-tot	0.0	42.6	46.5	26.9	28.0	0.0	0.0	98.9	119.7	84.5	181.3	0.0	2.4	188.9	272.4	409.3	189.8	14.7	1705.9	94.8	13034.663
gnd total	0.0	56.4	67.1	45.4	30.3	0.0	0.0	112.9	230.6	92.7	191.8	0.0	2.4	241.1	272.4	409.3	189.8	14.7	1956.9	108.7	14430.684

84126	12	6	85																		
	1	4	5	8	9	12	13	16	17	20	21	24	26	28	29	32	33	36	TOTAL	MEAN	VARIANCE
LAKE/POND																					
t < 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
t 5-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
t > 15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
t sub-tot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
s < 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
s 5-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
s > 15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
s sub-tot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
temp-tot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
p < 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	3.0	4.9	0.0	0.2	4.0	13.7	0.0	0.0	0.1	28.8	1.6	11.711
p 5-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1	6.6	0.0	0.0	12.7	0.7	4.224
p > 15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.2	1.4	35.280
perm-tot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.2	2.9	3.0	4.9	0.0	0.2	4.0	19.8	6.6	0.0	0.1	66.7	3.7	51.821
gnd total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.2	2.9	3.0	4.9	0.0	0.2	4.0	19.8	6.6	0.0	0.1	66.7	3.7	51.821
SHEETWATER																			TOTAL	MEAN	VARIANCE
t < 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
t 5-15	0.0	0.0	10.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.8	0.6	6.480
t > 15	0.0	0.0	130.0	90.3	0.0	145.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	158.0	523.3	29.1	3284.094
t sub-tot	0.0	0.0	140.8	90.3	0.0	145.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	158.0	534.1	29.7	3418.812
s < 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
s 5-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
s > 15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
s sub-tot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
temp-tot	0.0	0.0	140.8	90.3	0.0	145.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	158.0	534.1	29.7	3418.812
p < 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
p 5-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
p > 15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
perm-tot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
gnd total	0.0	0.0	140.8	90.3	0.0	145.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	158.0	534.1	29.7	3418.812
WATERCOURSE																			TOTAL	MEAN	VARIANCE
t < 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
t 5-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
t > 15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
t sub-tot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
s < 5	0.0	0.0	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	0.3	1.334
s 5-15	0.0	0.0	0.0	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.6	19.5	1.1	10.897
s > 15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
s sub-tot	0.0	0.0	4.9	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.6	24.4	1.4	11.606
temp-tot	0.0	0.0	4.9	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.6	24.4	1.4	11.606
p < 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
p 5-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
p > 15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
perm-tot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000
gnd total	0.0	0.0	4.9	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.6	24.4	1.4	11.606

Table C.3

CONFIDENCE INTERVALS FOR WETLAND ESTIMATES

BASIN	WETLAND ACREAGE ESTIMATES		
	LOWER CONFIDENCE LIMIT	ESTIMATED TOTAL	UPPER CONFIDENCE LIMIT
	------------	'000 acres	------------
Peace	2,967.0	3,817.0	4,667.0
Athabasca	1,105.2	1,997.0	2,888.8
Beaver	400.5	809.0	1,217.5
North Sask.	969.5	1,818.0	2,666.5
Battle	790.4	1,010.0	1,229.6
Red Deer	846.8	1,293.0	1,739.2
Bow	119.9	294.0	468.1
Oldman	178.2	276.0	373.8
South Sask.	138.0	637.0	1,136.0
Milk	59.7	116.0	172.3
TOTAL	10,351.2	12,067.0	13,782.9



Alberta

INVENTORY OF ALBERTA'S DRAINAGE REQUIREMENTS STUDY

SEPTEMBER 1986

FIGURE C.1

TOWNSHIPS PHOTOGRAPHED WITH EITHER COLOUR INFRARED OR COLOUR PHOTOGRAPHY (SCALE 1:50 000) DURING JULY-SEPTEMBER 1984

■ Colour infrared photos

⊡ Colour photos

PRODUCED BY THE RESOURCE EVALUATION AND PLANNING DIVISION, ALBERTA FORESTRY, LANDS AND WILDLIFE, 1986.

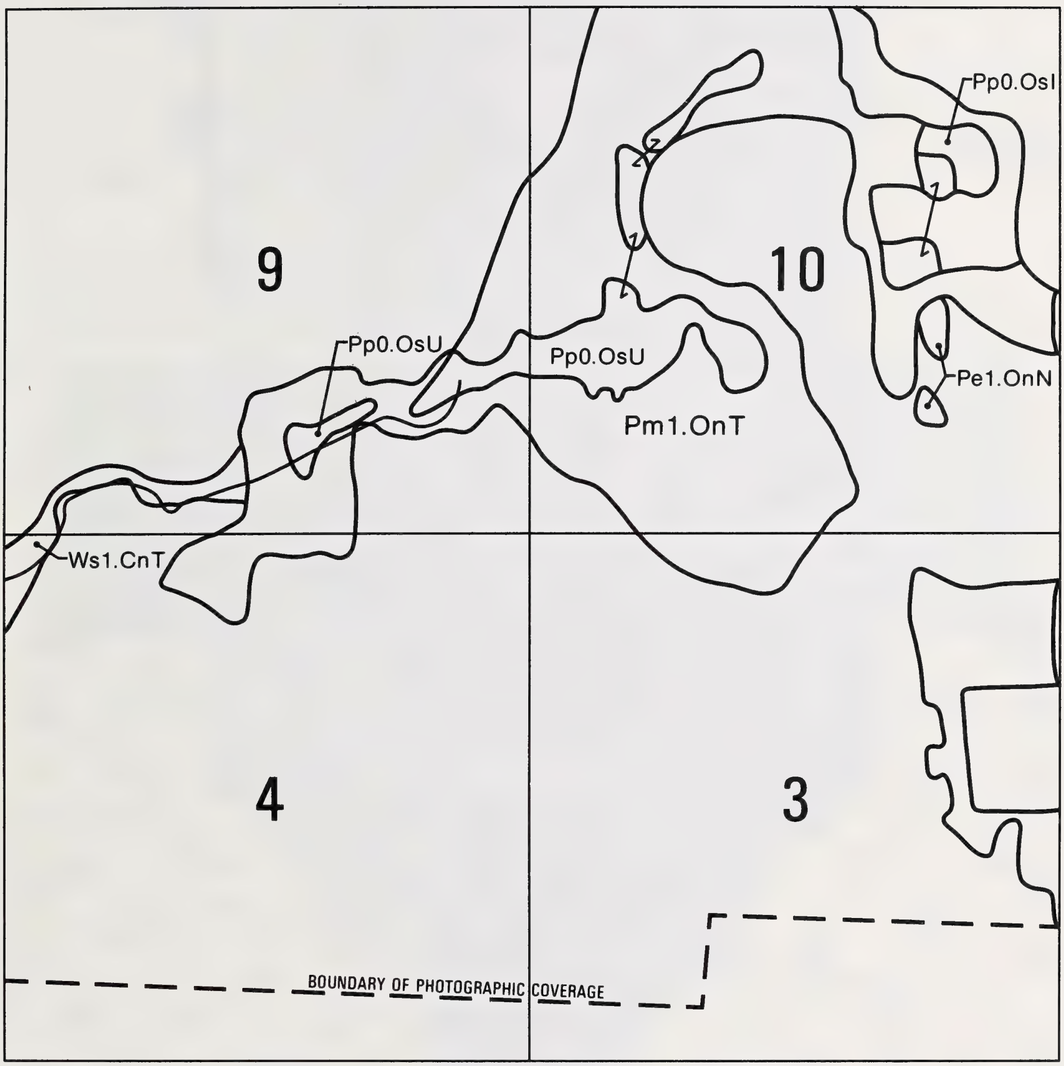
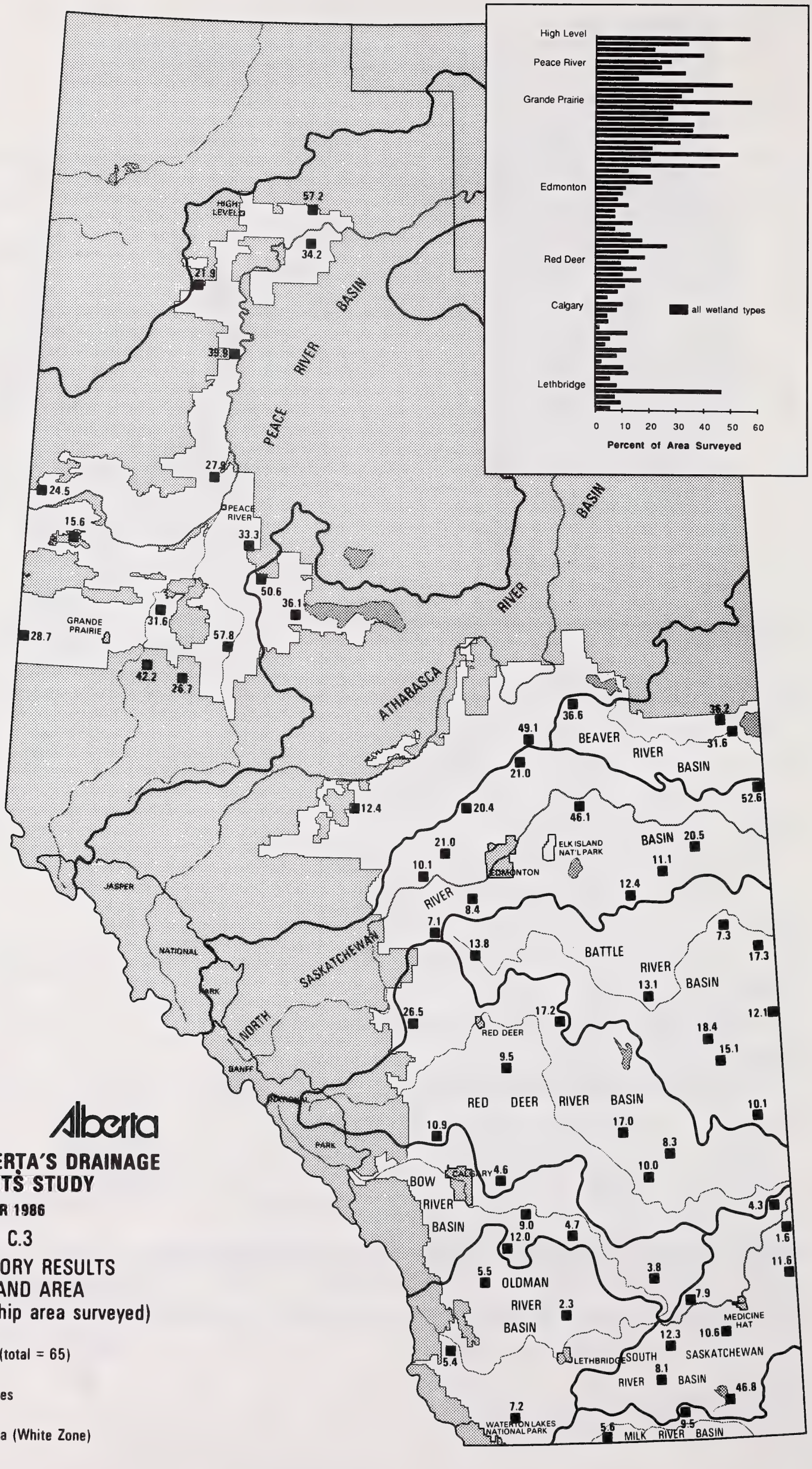


FIGURE C.2

Example of digitized 1:20000 scale map of four sections in the Lethbridge study area, as mapped from stereo interpretation of fall 1983 colour aerial photography. (Location: Township 11, Range 23, West of the 4th Meridian)

From: Intera Technologies Ltd. et al September 1984. Alberta Agricultural Wetlands Drainage Inventory: Phase I Aerial Photography Analysis and Ground Surveys, Volume 1 Final Report, p. 39.



Alberta

INVENTORY OF ALBERTA'S DRAINAGE REQUIREMENTS STUDY

SEPTEMBER 1986

FIGURE C.3

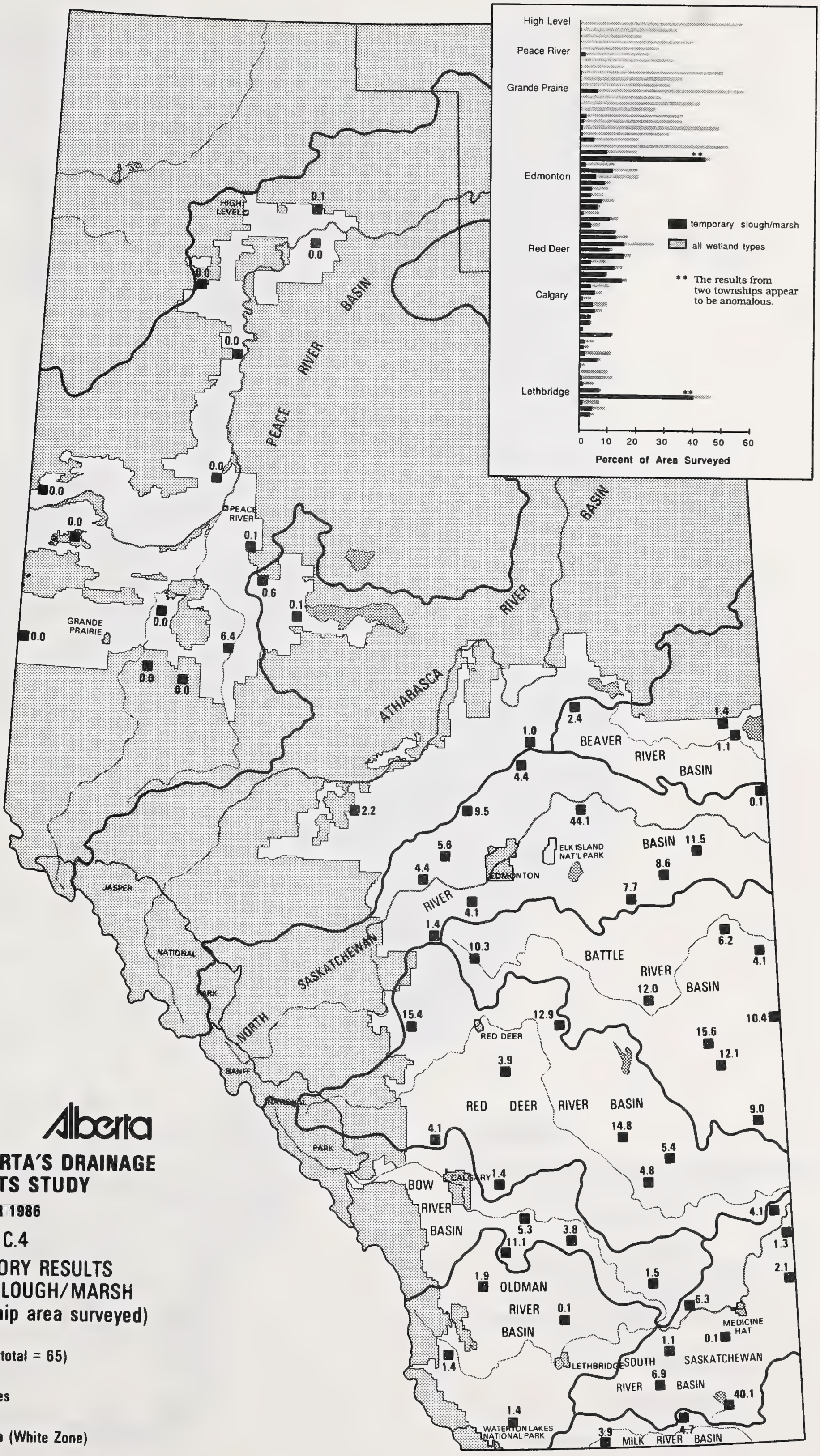
PHASE II INVENTORY RESULTS
TOTAL WETLAND AREA
(percentage of township area surveyed)

■ Townships sampled (total = 65)

— River basin boundaries

☐ Agricultural land area (White Zone)

PRODUCED BY THE RESOURCE EVALUATION AND PLANNING DIVISION, ALBERTA FORESTRY, LANDS AND WILDLIFE, 1986.



Alberta

INVENTORY OF ALBERTA'S DRAINAGE REQUIREMENTS STUDY

SEPTEMBER 1986

FIGURE C.4

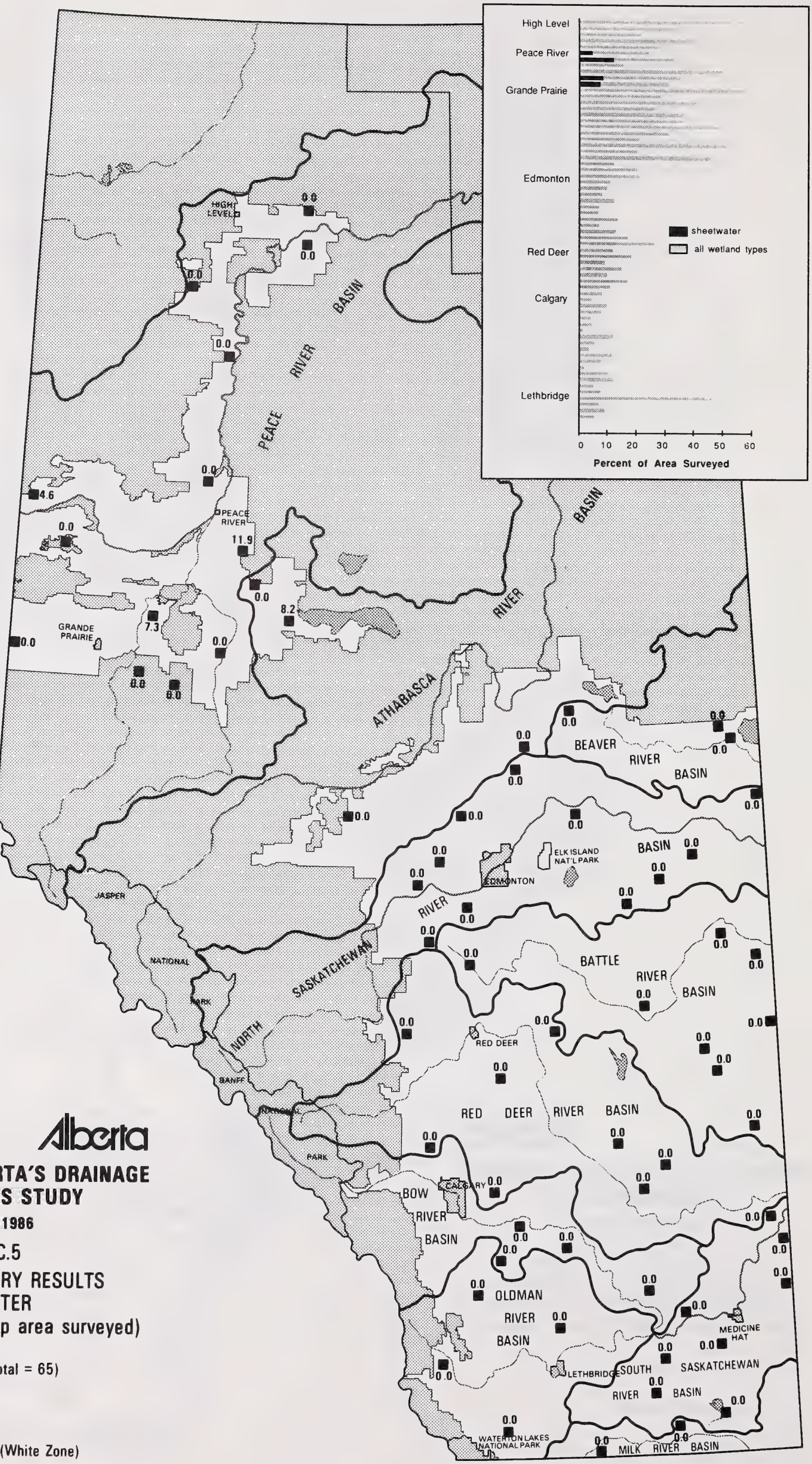
PHASE II INVENTORY RESULTS
NON-PERMANENT SLOUGH/MARSH
(percentage of township area surveyed)

■ Townships sampled (total = 65)

River basin boundaries

Agricultural land area (White Zone)

PRODUCED BY THE RESOURCE EVALUATION AND PLANNING DIVISION, ALBERTA FORESTRY, LANDS AND WILDLIFE, 1986.



Alberta

INVENTORY OF ALBERTA'S DRAINAGE REQUIREMENTS STUDY

SEPTEMBER 1986

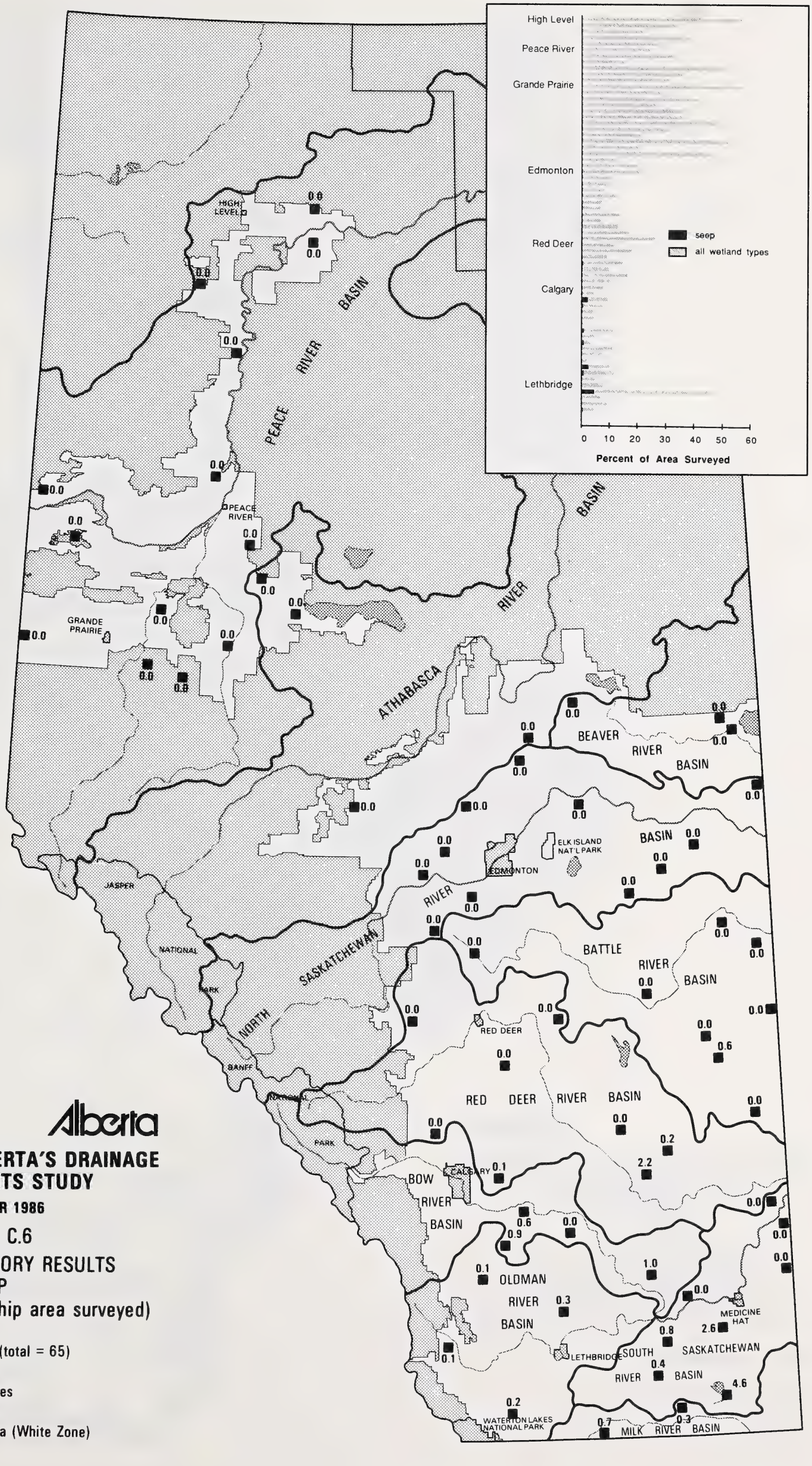
FIGURE C.5
PHASE II INVENTORY RESULTS
SHEETWATER
(percentage of township area surveyed)

■ Townships sampled (total = 65)

River basin boundaries

Agricultural land area (White Zone)

PRODUCED BY THE RESOURCE EVALUATION AND PLANNING DIVISION, ALBERTA FORESTRY, LANDS AND WILDLIFE, 1986.



Alberta

INVENTORY OF ALBERTA'S DRAINAGE REQUIREMENTS STUDY

SEPTEMBER 1986

FIGURE C.6

PHASE II INVENTORY RESULTS

SEEP

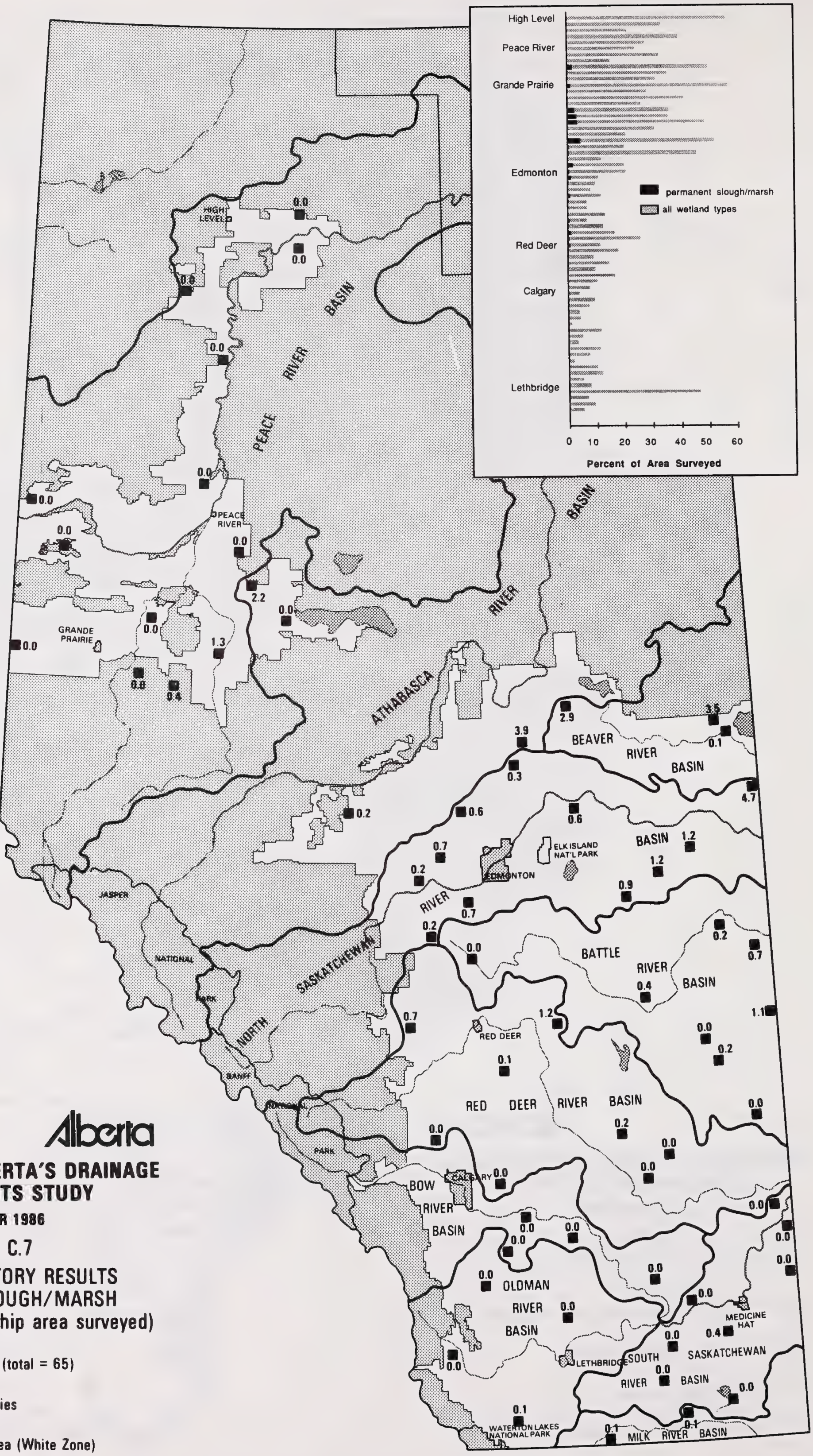
(percentage of township area surveyed)

■ Townships sampled (total = 65)

River basin boundaries

Agricultural land area (White Zone)

PRODUCED BY THE RESOURCE EVALUATION AND PLANNING DIVISION, ALBERTA FORESTRY, LANDS AND WILDLIFE, 1986.



Alberta

INVENTORY OF ALBERTA'S DRAINAGE REQUIREMENTS STUDY

SEPTEMBER 1986

FIGURE C.7

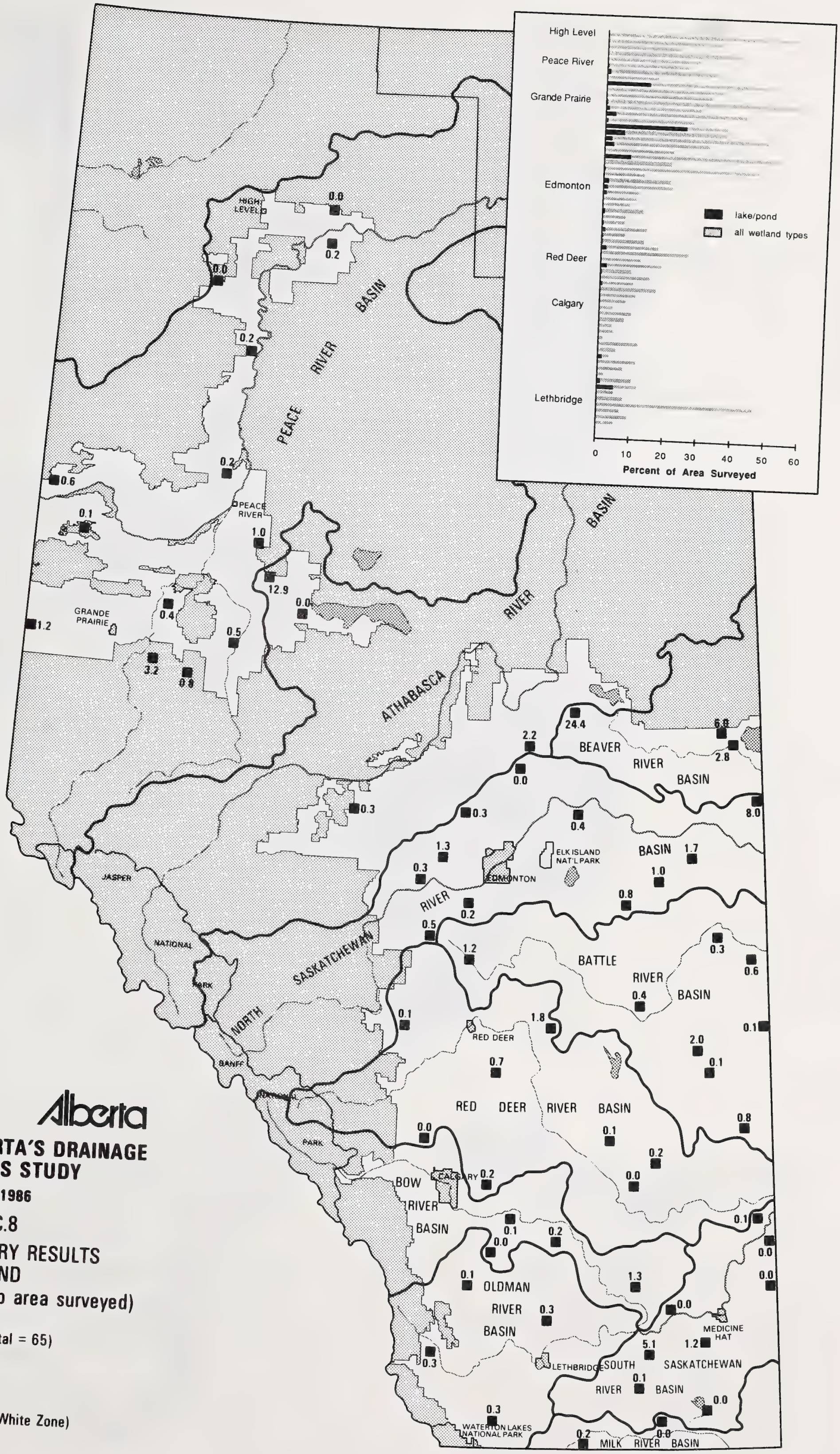
PHASE II INVENTORY RESULTS
PERMANENT SLOUGH/MARSH
(percentage of township area surveyed)

■ Townships sampled (total = 65)

River basin boundaries

Agricultural land area (White Zone)

PRODUCED BY THE RESOURCE EVALUATION AND PLANNING DIVISION, ALBERTA FORESTRY, LANDS AND WILDLIFE, 1986.



Alberta

INVENTORY OF ALBERTA'S DRAINAGE REQUIREMENTS STUDY

SEPTEMBER 1986

FIGURE C.8

PHASE II INVENTORY RESULTS

LAKE/POND

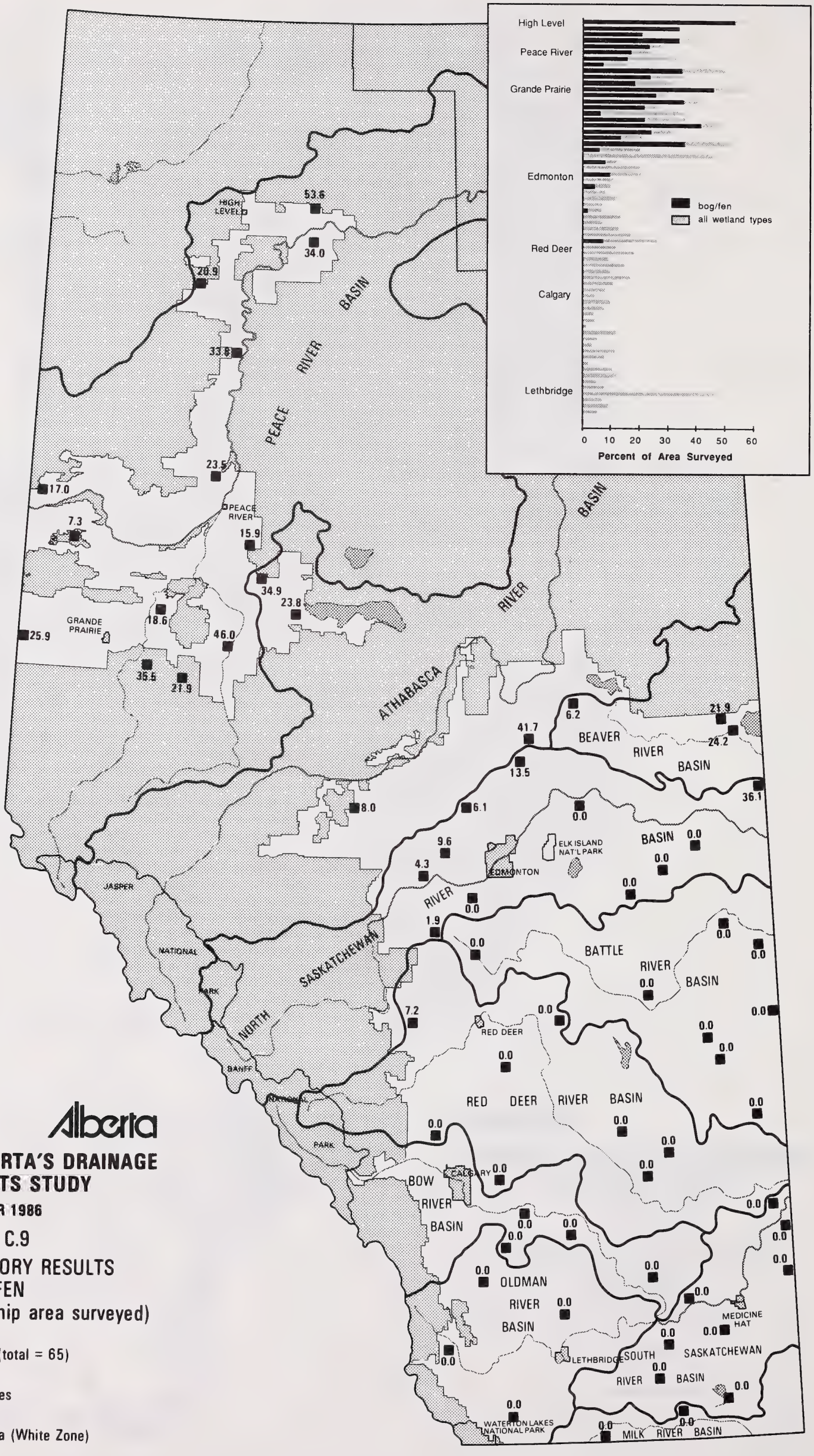
(percentage of township area surveyed)

■ Townships sampled (total = 65)

— River basin boundaries

☐ Agricultural land area (White Zone)

PRODUCED BY THE RESOURCE EVALUATION AND PLANNING DIVISION, ALBERTA FORESTRY, LANDS AND WILDLIFE, 1986



Alberta

INVENTORY OF ALBERTA'S DRAINAGE REQUIREMENTS STUDY

SEPTEMBER 1986

FIGURE C.9

PHASE II INVENTORY RESULTS

BOG/FEN

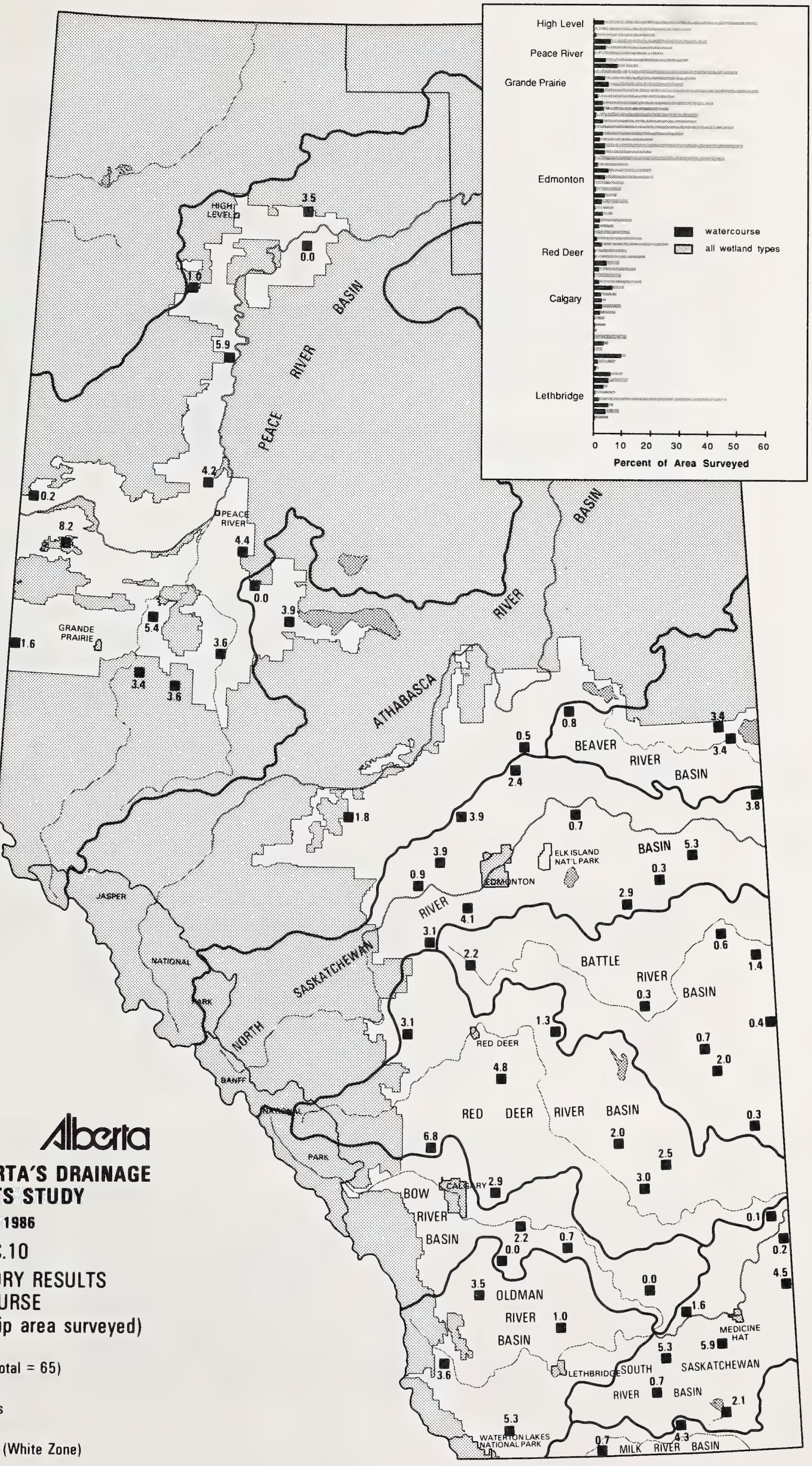
(percentage of township area surveyed)

■ Townships sampled (total = 65)

River basin boundaries

Agricultural land area (White Zone)

PRODUCED BY THE RESOURCE EVALUATION AND PLANNING DIVISION, ALBERTA FORESTRY, LANDS AND WILDLIFE, 1986.



Alberta

INVENTORY OF ALBERTA'S DRAINAGE REQUIREMENTS STUDY

SEPTEMBER 1986

FIGURE C.10

PHASE II INVENTORY RESULTS

WATERCOURSE

(percentage of township area surveyed)

■ Townships sampled (total = 65)

— River basin boundaries

☐ Agricultural land area (White Zone)

PRODUCED BY THE RESOURCE EVALUATION AND PLANNING DIVISION, ALBERTA FORESTRY, LANDS AND WILDLIFE, 1986.

APPENDIX D

MINI-BASIN STUDY RESULTS

APPENDIX D

D.1 Silver Creek

D.1.1 Introduction

Silver Creek flows easterly and then northerly to its confluence with the Battle River at the upstream end of Driedmeat Lake. Approximately the last four miles of the creek are deeply incised as the creek descends to the Battle River.

The topography of the mini-basin ranges from EL 2650 feet in the southwest to EL 2400 at the top of the Battle River valley wall, which abruptly drops a further 125 feet to the valley floor. The western part of the area has hummocky moraine as the dominant landform. The central portion of the mini-basin is flatter, with the eastern part being the flattest. The western third of the mini-basin has approximately 62 percent of all permanent wetland acres, whereas the central portion has a high density of shallow non-permanent wetlands (Plate 1, main body of the report). The easterly portion has significantly fewer wetlands.

Improvements to the main channel were undertaken in 1984 which included the drainage of wetlands immediately adjacent to Silver Creek. It is evident that extensive unauthorized private drainage has been implemented.

The wetland composition and upland land use of the basin are shown in Figure 3.3 and Table 3.1 (Section 3.4.1 in the main report). The Silver Creek basin is 53.5 sections in size.

The drainage scenarios examined in this basin are:

1. TOTAL DRAINAGE: Drain all wetlands except watercourses (5349 acres).
2. PARTIAL DRAINAGE: Drain all non-permanent wetlands (4040 acres).
3. CONSOLIDATION: Consolidate non-permanent wetlands (4040 acres).

D.1.2 Hydrotechnical Aspects

The expected peak runoff from the total and partial drainage scenarios, which would have to be accommodated by the off-farm drainage network, are given in Table D.1. The capital costs for these works are presented in Table D.2 and do not include operation and maintenance costs.

D.1.3 On-Farm Drainage Engineering

The Silver Creek mini-basin provides a good representation of farm drainage activity in much of east central Alberta, where numerous sloughs and potholes occur within cultivated fields. Drainage methods in use include surface ditching and sub-surface pipe. Shallow wetlands can be most economically drained with ditches, while underground pipe is particularly suited to deep sloughs or lake/ponds in undulating terrain. Factors which

influence the method selected and the costs per acre include wetland size, depth, soil type, outlet availability and obstructions (utility lines, roads, etc.).

The capital costs to drain an average section of land using the most practical and economical combination of surface and sub-surface methods are presented in Table D.3.

D.1.4 Soils and Agronomy

The Silver Creek mini-basin lies in a well developed agricultural area producing a mixture of cereal crops, forage and livestock. Information on the soils, farming activities and existing drainage in the basin is found in Leskiw (1987).

Table D.4 summarizes the agricultural costs and benefits that were quantified in this study. These are based on an assumed schedule of installation of drainage works in year one and land preparation activities and introduction of crops over a period of five years in total.

The costs and benefits shown in Table D.4 and in Anderson (1987) were used as the basis for the final economic and financial results shown in the body of this report. They cannot be compared directly to those final results since changes were made in the discount rate, the treatment of depreciation, financing and income taxes, and the base year for costs. These changes were made so that the methodology of this study would correspond exactly to that used in the Agricultural Land Base Study (MacDonald-Date, et. al., 1986; Alberta Agriculture, 1986)

D.1.5 Wildlife and Fisheries

D.1.5.1 Wildlife. The large numbers and diversity of wetlands within the Silver Creek mini-basin provide important habitat for aquatic and semi-aquatic wildlife, particularly waterfowl and other waterbirds. Land surrounding the wetlands, which is not cultivated, provides valuable habitat for upland species, such as game birds and ungulates, as well as nesting habitat for waterfowl.

Small (less than one acre) non-permanent wetlands provide breeding habitat for dabbling ducks, while larger, deeper wetlands are used by diving ducks, and by dabblers for brood-rearing and post-breeding habitat. The western part of the mini-basin provides excellent waterfowl habitat, featuring rolling topography with well vegetated, interspersed wetlands.

Table D.5 shows the proportional habitat losses for each species group under each drainage scenario; and the mitigation costs for habitat replacement are in Table D.6. The costs of 50 percent wildlife mitigation are approximately half those shown for total mitigation.

D.1.5.2 Fisheries. Silver Creek enters the Battle River immediately upstream of Driedmeat Lake. The CLI sport-fish capability rating for the Silver Creek watershed indicates severe limitations on sport-fish production, because of inadequate creek flows and shallow water depth. A spring investigation of the Silver Creek basin (Fernet, 1987) confirmed that it

exhibits no fish habitat potential. Therefore, mitigation measures or enhancements would not be required for fisheries in the mini-basin.

Drainage in the Silver Creek basin could affect the habitat conditions for fish in the Battle River, which has several limitations to sport fish production. The most adverse of these are periods of low flows and oxygen depletion. Northern pike, the only sport species in the region, migrate through the stretch of the Battle River at the mouth of Silver Creek, and likely use the confluence area for spawning, rearing and summer feeding. Suitability of the habitat in this part of the Battle River declines as summer progresses, and although some fish over-winter downstream in Driedmeat Lake, many often winterkill due to the combination of low flows and low oxygen availability.

Despite these limitations, the Battle River provides one of the very few sport fishery opportunities in this geographic region of the province, and is a fishery which is heavily used by local people during both summer and winter seasons. The potential for use of the river by sport fishes is evaluated as good. However, to realize this potential, eutrophication of the river must be stopped and reversed, and flows augmented during low discharge periods.

Based on fieldwork and various studies of the fisheries of the area, drainage of the Silver Creek basin would minimally effect the hydrograph of the Battle River. Despite the small effect drainage might have, it would nonetheless aggravate the existing environmental problems in the drainage basin. The drainage of a number of small watersheds could, however, significantly affect the hydrology (by accentuating the peaks and the low flows) and the water quality of the Battle River.

Controlled drainage would not have as drastic an effect on flows and water quality as uncontrolled drainage. The flow controls would reduce the amount of sediment discharged off-farm and provide a more stable rate of flow. Consolidation could provide many benefits to the local fishery. Downstream water quality would improve because of settling of sediments and uptake of nutrients by the pond vegetation. Downstream flow rates would be stabilized, reducing periods of low flows and habitat degradation from erosion. The ponds themselves could be used for put-and-take trout fisheries.

Other rivers in central and southern Alberta, which have no mountain tributaries and little or no storage or flow control, may have similar fisheries problems as discussed for the Battle River, and could likewise benefit from consolidation efforts.

D.1.6 Economic Analysis

The results of the on-farm financial analysis are presented in Table 3.2 and for public direct benefits and costs in Table 3.3 in the main report (Section 3.4.1). Details of the breakdown of costs and benefits can be found in Anderson (1987). The costs and benefits reported by Anderson were, however, only used as the basis for the economic and financial results shown in the body of this report, as mentioned above.

Table D.1

SILVER CREEK PEAK RUNOFF

Scenario	Outflow (cfs) Uncontrolled	Controlled*
Existing Conditions	420	
Total Drainage	1,070	700
Partial Drainage	1,020	700

*There is no difference between the two scenarios as the flow is restricted to 5.6 cfs as it leaves each section.

Table D.2

SILVER CREEK OFF-FARM DRAINAGE COSTS

COSTS	CONTROLLED DISCHARGE [1]		UNCONTROLLED DISCHARGE
	Total Drainage ($) 1985	Partial Drainage ($) 1985	Partial Drainage ($) 1985
BASIN TOTAL [2]	$4,417,000	$4,417,000	$10,600,000
Cost/ Acre Drained Cost / Average Section	$825 $82,500	$1,100 $82,500	$2,620 $197,980

[1] Assumes off-farm discharge is restricted to 5.6 cfs per square mile, using flow restriction at the farm boundary.

[2] Total costs do not change for drainage of all or just non-permanent wetlands because of the flow restriction outlined above. The unit cost/acre of wetlands is higher for the latter case, because fewer acres of wetland are drained.

Table D.3

SILVER CREEK ON-FARM DRAINAGE COSTS

DRAINAGE SCENARIOS	BASIN AREA AFFECTED			COSTS		
	Wetland Area Drained (acres)	Grassed Ditches Area (acres)	Consolidation Pond Area Required (acres)	TOTAL (million $)	$ per average section	$ per acre drained
I. TOTAL - Drain all wetlands except watercourses	5,349	400	-----	3.21	60,000	600
II. PARTIAL - Drain non-permanent wetlands	4,040	300	-----	2.05	38,320	507
III. CONSOLIDATION- Drain & consolidate non-permanent wetlands	4,040	300	933	4.76	89,000	1,178

Table D.4

SILVER CREEK AGRICULTURAL COSTS AND BENEFITS OF DRAINAGE

FACTOR	DRAINAGE SCENARIO					
	TOTAL DRAINAGE		PARTIAL DRAINAGE		CONSOLIDATION	
	When? [1]	$ per average section	When? [1]	$ per average section	When? [1]	$ per average section
COSTS [2]						
(1) Land Area Preparation	Year 2 Year 3	$9,806 $2,609	Year 2 Year 3	$8,168 $2,336	Year 2 Year 3	$8,168 $2,336
(2) Lost Revenue from Ditch Areas	Years 1 & 3+ Year 2	$335 $858	Years 1 & 3+ Year 2	$250 $643	Years 1 & 3+ Year 2	$250 $643
BENEFITS						
(1) Net Revenue from drained wetland areas (crop revenues minus crop production costs)	Year 3 Year 4 Year 5 Year 6 Year 7+	($775) $320 $3,842 $5,077 $5,417	Year 3 Year 4 Year 5 Year 6+	$376 $1,914 $2,947 $4,321	Year 3 Year 4 Year 5 Year 6+	($755) $783 $1,816 $3,188
(2) Improved crop quality-transitional	Year 3 Year 4+	$318 $622	Year 3 Year 4+	$239 $471	Year 3 Year 4+	$239 $471
(3) Improved crop quality - uplands	Year 2+	$1,133	Year 2+	$1,133	Year 2+	$1,078
(4) Improved timing	Year 4+	$2,832	Year 4+	$2,832	Year 4+	$2,693
(5) Reduced transitional area costs	Year 3 Year 4+	$527 $1,032	Year 3 Year 4+	$398 $779	Year 3 Year 4+	$398 $776
(6) Improved field Efficiency	Year 3 Year 4+	$402 $787	Year 3 Year 4+	$288 $628	Year 3 Year 4+	$288 $628

[1] Indicates the years in which the costs or benefits occur. A (+) sign indicates that the cost or benefit continues annually to the end of the thirty year life of the project. Drainage works are assumed to be constructed in Year 1. As is evident, some benefits do not begin immediately.

[2] Costs not shown in this table include the capital costs for drainage (See Table D.3) and the annual operation and maintenance costs which begin in Year 2.

This table is based on Tables B-1 to B-3 of Anderson (1987), p. 87-90.

Table D.5

SILVER CREEK HABITAT LOSSES FROM EACH DRAINAGE SCENARIO

Wildlife Species Group	Percent Habitat Lost		
	Total Drainage	Partial Drainage	Consolidation
Dabbling Waterfowl	100	66	59
Diving Waterfowl	100	61	56
Marsh Shorebirds	100	66	63
Songbirds	100	70	63
Upland Game Birds	100	71	63
Ungulates	100	68	56
Open Water Furbearers	100	43	29
Marshland Furbearers	100	54	45
Ground-dwelling Wildlife	100	80	74
Average	100	64	57

Table D.6

SILVER CREEK WILDLIFE MITIGATION COSTS

Total Drainage	
Total cost	$12,985,947
Per Average Section	$242,536
Per Acre Drained	$2,428
Partial Drainage	
Total cost	$8,247,555
Per Average Section	$154,038
Per Acre Drained	$2,041
Consolidation	
Total cost	$1,652,401
Per Average Section	$30,861
Per Acre Drained	$409

NOTE: Silver Creek Mini-Basin Area = 53.54 sections

D.2 Shoal Creek

D.2.1 Introduction

The Shoal Creek study area includes the upper portion of the entire Shoal Creek basin. Specifically in contains Shoal Lake (approximately 2000 acres), three watercourses draining into the lake, and approximately three miles of Shoal Creek, originating at Shoal Lake and eventually draining into the Pembina River. The lake level is controlled by a Ducks Unlimited weir.

The land slopes eastward with a difference in relief of approximately 150 feet across the basin. Till, glaciolacustrine clay and silt, and organic deposits cover most of the basin. The organic deposits occur within topographic lows.

A drainage network has been established in the vicinity of Shoal Lake with five drainage ditches and several small creeks. The channels are generally in poor condition, overgrown with vegetation, and have numerous beaver dams. Six miles of Camp Creek, one of the watercourses flowing into Shoal Lake, were improved in the early 1970's; however, flooding complaints have been recorded since 1978.

In general, the regional groundwater flow is southwestward, toward the Pembina River. The local groundwater flow regime has recharge taking place within hilly/sand deposits with discharge to topographic lows. Most groundwater wells produce water from the bedrock aquifers with only 6.5 percent drawing water from surficial deposits. Draining the wetlands in the Shoal Creek basin will likely have a negligible effect on recharge to the intermediate depth groundwater regime from which domestic users extract water.

The wetland composition and land use of the basin are shown in Figure 3.4 and Table 3.4 (Section 3.4.2 in the main report). The Shoal Creek basin is 94.7 sections in size.

The drainage scenarios examined in this basin are:

1. TOTAL DRAINAGE: Drain all wetlands except watercourses and Shoal Lake (19,926 acres).
2. PARTIAL DRAINAGE: Drain all non-permanent wetlands (972 acres).
3. CONSOLIDATION: (a) Drain and consolidate non-permanent wetlands (972 acres).
   (b) Drain and consolidate bog/fen (17,856 acres).

D.2.2 Hydrotechnical Aspects

The expected peak runoff from the total and partial drainage scenarios, which would have to be accommodated by an off-farm drainage network, are given in Table D.7. The capital costs, excluding operation and maintenance costs, for these works are presented in Table D.8.

D.2.3 On-Farm Drainage Engineering

Most farmers have given drainage priority to the isolated sloughs and small peat bogs which hamper efficient field operations. Techniques such as shallow ditches and filling have been used to drain these wetlands. Not as much drainage has taken place in the large bogs because the productivity of peat soils is uncertain and the drainage technology is still being developed. As the desire for new land and greater production increases, farmers are experimenting with ways to develop the organic soils in the area. Drainage is usually accomplished by construction of steep-sided ditches to lower the water table enough to permit land clearing operations and tilling or removal of coarse peat.

The capital costs to drain an average section of land using the most practical and economical combination of surface and sub-surface methods are presented in Table D.9. Consolidation of drainage outflow from the non-permanent wetlands may be practical but consolidation of bog/fen discharge has both economic and technical constraints.

D.2.4 Soils and Agronomy

The Shoal Creek mini-basin lies in a developing agricultural area. About 55 percent of the basin is cultivated, growing mostly forage and some cereal crops. Of the 38 percent of its area that is classified as wetland, almost 80 percent is bog/fen. Information on the soils, farming activities and existing drainage in the basin is found in Leskiw (1987).

Table D.10 summarizes the agricultural costs and benefits that were quantified in this study. These are based on an assumed schedule of installation of drainage works in year one and land preparation activities, introduction of crops and stabilization of production over a period of seven years in total.

The costs and benefits shown in Table D.10 and in Anderson (1987) were used as the basis for the final economic and financial results shown in the body of this report. They cannot be compared directly to those final results since changes were made in the discount rate, the treatment of depreciation, financing and income taxes, and the base year for costs. These changes were made so that the methodology of this study would correspond exactly to that used in the Agricultural Land Base Study (MacDonald-Date, et. al., 1986; Alberta Agriculture, 1986).

D.2.5 Wildlife and Fisheries

D.2.5.1 Wildlife. The Shoal Creek basin provides good habitat for bog/fen shorebirds, open water furbearers and dabbling waterfowl. Marsh shorebirds, ungulates and diving ducks have the least amount of habitat. Bog/fen areas, because of their extensive size, provide the greatest total amount of habitat for all of the wildlife species groups. Shoal Lake also is an important area of habitat for most wildlife species. In contrast, non-permanent wetlands and watercourses provide only a small amount of the total habitat. Most of the shrub and tree covered lands in the basin are associated with wetlands, especially bog/fens, so this upland habitat will also be affected if drainage proceeds.

Table D.11 shows the proportional habitat losses for each species group under each drainage scenario; the mitigation costs for habitat replacement are in Table D.12. The costs of 50 percent wildlife mitigation are approximately half those shown for total mitigation.

D.2.5.2 Fisheries. There is no fisheries potential in the Shoal Creek mini-basin at this time so mitigation within the watershed would not be required. Shoal Creek, its tributaries, and the wetlands within the mini-basin have numerous and severe limitations for sport-fish production due to shallow water, low flows or extreme flow fluctuations and the presence of many obstacles in the creek. Northern pike have ascended the creek as far as the lake outlet to spawn, but this is not an annual event. Shoal Creek is presently undergoing channelization including the installation of two drop structures that will prevent upstream fish passage. Shoal Lake is too shallow to support a viable fishery.

The mouth of the creek at the Pembina River is not currently used by fish. Changes in flows and water quality caused by drainage could, however, have some impact on the Pembina by accentuating extreme flows (low and high) and by increasing erosion and sedimentation.

The characteristics of Shoal Creek in terms of fisheries use appear to be applicable to the vast majority of comparably sized watercourses entering the Pembina system. The analysis, therefore, appears to be suitable for extrapolation to the watershed in general.

D.2.6 Economic Analysis

The results of the on-farm financial analysis are presented in Table 3.5 and for public direct benefits and costs in Table 3.6 in the main report (Section 3.4.2). Details of the breakdown of costs and benefits can be found in Anderson (1987). The costs and benefits reported by Anderson were, however, only used as the basis for the economic and financial results shown in the body of this report, as mentioned above.

Table D.7

SHOAL CREEK PEAK RUNOFF

Scenario	Outflow (cfs) Uncontrolled	Controlled
Existing Conditions	462	
Total Drainage	1,931	669
Partial Drainage	538	538

Table D.8

SHOAL CREEK OFF-FARM DRAINAGE COSTS

COSTS	CONTROLLED DISCHARGE [1]		UNCONTROLLED DISCHARGE
	Total Drainage ($) 1985	Partial Drainage ($) 1985	Total Drainage ($) 1985
BASIN TOTAL	$5,700,000	$1,030,000	$12,100,000
Cost/Acre Drained Cost/Average Section	$286 $62,700	$1,060 $11,300	$607 $133,110

[1] Assumes off-farm discharge is restricted to 4.0 cfs per square mile, using flow restriction at the farm boundary.

Table D.9

SHOAL CREEK ON-FARM DRAINAGE COSTS

DRAINAGE SCENARIOS	BASIN AREA AFFECTED			COSTS		
	Wetland Area Drained (acres)	Grassed Ditches Area (acres)	Consolidation Pond Area Required (acres)	TOTAL (million $)	$ per average section	$ per acre drained
I. TOTAL - Drain all wetlands except watercourses	19,926	276	-----	3.00	33,000	150
II. PARTIAL - Drain non-permanent slough/marsh	972	110	-----	0.35	3,850	360
III. CONSOLIDATION - Drain & consolidate:						
(a) non perm. slough/marsh	972	110	275	1.00	11,000	1,030
(b) Bog/Fen	17,856	166	1,098	13.73	151,265	770

Table D.10

SHOAL CREEK AGRICULTURAL COSTS AND BENEFITS OF DRAINAGE

FACTOR	DRAINAGE SCENARIO					
	TOTAL DRAINAGE		PARTIAL DRAINAGE		CONSOLIDATION	
	When? [1]	$ per average section	When? [1]	$ per average section	When? [1]	$ per average section
COSTS [2]						
(1) Land Area Preparation	Year 2 Year 3 Year 4	$5,407 $26,590 $25,916	Year 2 Year 3	$5,407 $1,640	Year 2 Year 3	$5,407 $1,640
(2) Lost Revenue from Ditch Areas	Years 1 & 3+ Year 2	$157 $361	Years 1 & 3+ Year 2	$62 $144	Years 1 & 3+ Year 2	$62 $144
BENEFITS						
(1) Net Revenue from drained wetland areas (crop revenues minus crop production costs)	Year 3 Year 4 Year 5 Year 6 Year 7+	($37) ($964) ($778) $6,754 $10,984	Year 3 Year 4 Year 5 Year 6+	($37) ($292) $2,228 $1,963	Year 3 Year 4 Year 5 Year 6+	($681) ($610) $910 $1,645
(2) Improved crop quality-transitional	Year 3 Year 4 Year 5+	$3 $108 $271	Year 3 Year 4 Year 5+	very small $5 $14	Year 3 Year 4 Year 5+	very small $5 $14
(3) Improved crop quality - uplands	Year 2+	$215	Year 2+	$11	Year 2+	$11
(4) Improved timing	Year 4+	$215	Year 4+	$11	Year 4+	$11
(5) Reduced transitional area costs	Year 3 Year 4 Year 5+	$4 $116 $294	Year 3 Year 4 Year 5+	very small $5 $15	Year 3 Year 4 Year 5+	very small $5 $15
(6) Improved field Efficiency	Year 3 Year 4 Year 5+	$15 $441 $1,116	Year 3 Year 4+	$9 $108	Year 4+	$144

[1] Indicates the years in which the costs or benefits occur. A (+) sign indicates that the cost or benefit continues annually to the end of the thirty year life of the project. Drainage works are assumed to be constructed in Year 1. As is evident, some benefits do not begin immediately.

[2] Costs not shown in this table include the capital costs for drainage (See Table D.9) and the annual operation and maintenance costs which begin in Year 2.

This table is based on Tables B-7 to B-9 of Anderson (1987), p. 96-100.

Table D.11

SHOAL CREEK HABITAT LOSSES FROM EACH DRAINAGE SCENARIO

Wildlife Species Group	Percent Habitat Lost		
	Total Drainage	Partial Drainage	Consolidation
Dabbling Waterfowl	84	7	4
Diving Waterfowl	75	7	5
Marsh Shorebirds	72	8	6
Bog/fen Shorebirds	91	6	4
Songbirds	86	8	5
Upland Game Birds	93	8	4
Ungulates	91	8	4
Open Water Furbearers	79	3	1
Marshland Furbearers	77	5	3
Ground-dwelling Wildlife	95	8	6
Average	84	7	4

Table D.12
SHOAL CREEK WILDLIFE MITIGATION COSTS

Total Drainage	
Total cost	$4,212,203
Per Average Section	$46,339
Per Acre Drained	$210
Partial Drainage	
Total cost	$2,405,595
Per Average Section	$26,464
Per Acre Drained	$2,475
Consolidation	
Total cost	$488,410
Per Average Section	$5,373
Per Acre Drained	$502

NOTE: Shoal Creek Mini-Basin Area = 53.54 sections (excluding Shoal Lake)

D.3 Lalby Creek

D.3.1 Introduction

The Lalby Creek mini-basin terrain is generally flat, with an elevation change of only 125 feet from the head of the basin to the confluence of Hunting Creek and the Smoky River in the southwest. Lalby Creek exists as a clearly defined channel only in the southwestern portion of the mini-basin, where it is a shallow, treed channel with little or no opportunity for flood water storage.

A large lake covering 2.5 sections, Lac Magloire, is located in the east central portion of the basin. This lake acts as a storage reservoir for runoff from the eastern portion of the basin, moderating peak flows from lands in that part of the basin. Lake levels are controlled by a weir at the outlet to Lalby Creek.

Most residents rely on surface dugouts to meet their domestic water needs, because of the scarcity of suitable groundwater yields in the surficial and shallow bedrock deposits.

Over 61 percent of the basin is cultivated, the eastern portion contains the more recently cleared land and most of the uncleared. Wetlands cover 29 percent of the basin with sheetwater being the dominant type. Sheetwater is a temporary, shallow flooding of cultivated lands that prevents farmers from getting on the land early enough in the spring and causes crop loss through drowning after a spring or summer storm. Some farmers are attempting to remove this water by shallow V-ditches, but, due to the overall lack of slope, they have infrequent success. The wetland composition and upland land use of the basin are shown in Figure 3.5 and Table 3.7 (Section 3.4.3 in the main report). The Lalby Creek basin is 67.5 sections in size.

The drainage scenarios examined in this basin are:

1. TOTAL DRAINAGE: Drain bog/fen and non-permanent wetlands; permanent slough/marsh and lake/pond not included because Lac Magloire represents about 95 percent of them (10,000 acres).
2. PARTIAL DRAINAGE: Drain all non-permanent wetlands (8595 acres).
3. CONSOLIDATION: Drain and consolidate non-permanent wetlands (8595 acres).

D.3.2 Hydrotechnical Aspects

The expected peak runoff from the total and partial drainage scenarios, which would have to be accommodated by an off-farm drainage network, are given in Table D.13. The capital costs, excluding operation and maintenance costs, for these works are presented in Table D.14.

D.3.3 On-Farm Drainage Engineering

Sheetwater causes the most serious agricultural losses in the Lalby Creek basin. In sheetwater areas snowmelt often delays or prevents seeding in the spring, summer rainfall may cause flooding of growing crops, and fall rains can restrict access of harvesting equipment. Farmers have attempted to remove excess water by individual or group drainage projects which direct runoff to road ditches. This activity has often resulted, however, in flooding of downstream properties.

The capital costs to drain an average section of land using the most practical and economical combination of surface and sub-surface methods are presented in Table D.15. Consolidation would require about six acres per section for storage ponds.

D.3.4 Soils and Agronomy

The Lalby Creek mini-basin lies in a developing agricultural area, producing a mixture of forage and cereal crops. The most intensive areas of cultivation are also the areas of most extensive sheetwater occurrence. These wetlands result from a combination of flat topography, low infiltration rates, shallow topsoil depths, impermeable subsoils and lack of drainage outlets. In the higher regions of the basin (generally northeast), there is a greater potential for gully erosion due to the fine textured soils. Information on the soils, farming activities and existing drainage in the basin is found in Leskiw (1987).

Table D.16 summarizes the agricultural costs and benefits that were quantified in this study. These are based on an assumed schedule of installation of drainage works in year one and land preparation activities, introduction of crops and stabilization of production over a period of seven years in total.

The costs and benefits shown in Table D.16 and in Anderson (1987) were used as the basis for the final economic and financial results shown in the body of this report. They cannot be compared directly to those final results since changes were made in the discount rate, the treatment of depreciation, financing and income taxes, and the base year for costs. These changes were made so that the methodology of this study would correspond exactly to that used in the Agricultural Land Base Study (MacDonald-Date, et. al., 1986; Alberta Agriculture, 1986).

D.3.5 Wildlife and Fisheries

D.3.5.1 Wildlife. Most wetlands in the Lalby Creek basin are of moderate value to wildlife. Lac Magloire has the highest ranking for all wildlife types, providing moderate to good quality habitat; followed by bog/fens and non-permanent slough/marsh. Sheetwater has the lowest valued habitat, but because of the large areas it covers, provides the third most extensive habitat, after Lac Magloire and bog/fens. Bog/fens are most important for shorebirds, ungulates, open water furbearers, upland gamebirds and dabbling waterfowl; whereas sheetwater is important for ground-dwelling animals, bog/fen shorebirds, songbirds, upland gamebirds and ungulates.

A weir has been installed at the outlet of Lac Magloire to stabilize water levels and reduce flooding on adjacent farmland. Ducks Unlimited also completed a waterfowl habitat enhancement project as part of this program. Further modification of Lac Magloire for wildlife habitat mitigation or drainage consolidation is unlikely.

Table D.17 shows the proportional habitat losses for each species group under each drainage scenario; and the mitigation costs for habitat replacement are in Table D.18. The costs of 50 percent wildlife mitigation are approximately half those shown for total mitigation.

D.3.5.2 Fisheries. There is no fisheries potential in Lalby Creek or its watershed. Lalby Creek and its associated wetlands exhibit numerous and severe limitations for sport-fish production. The factors limiting productivity are infrequency and shallowness of pools in the watercourses, and the low flows or extreme fluctuations in flow. Lac Magloire is too shallow to support fish.

Lalby Creek discharges into Hunting Creek, which also has no fishery use or potential. At the mouth of Hunting Creek, where it joins the Smoky river, there may be some spring spawning by Arctic grayling, walleye, goldeye and northern pike. Mouths of tributaries such as Hunting Creek that have clearer, calmer water than the fast flowing, turbid main stem rivers tend to be important holding and feeding areas for the fish.

Drainage activities within the Lalby Creek basin could alter fish habitat at the mouth of Hunting Creek due to alteration of creek flows, in terms of quantity and timing, and changes in water quality, notably suspended sediment, during the spring spawning period. These factors in combination could produce several negative impacts including the erosion or siltation of spawning and feeding areas. Spawning fish may also ascend Hunting Creek during a high flow period and then become stranded if discharge declines rapidly.

Such habitat alteration on a larger scale, such as if drainage of many small basins like Lalby Creek took place, might seriously affect the Smoky River fishery.

D.3.6 Economic Analysis

The results of the on-farm financial analysis are presented in Table 3.8 and for public direct benefits and costs in Table 3.9 in the main report (Section 3.4.3). Details of the breakdown of costs and benefits can be found in Anderson (1987). The costs and benefits reported by Anderson were, however, only used as the basis for the economic and financial results shown in the body of this report, as mentioned above.

Table D.13

LALBY CREEK PEAK RUNOFF

Scenario	Outflow (cfs)	
	Uncontrolled	Controlled
Existing Conditions	690	
Total Drainage	1,560	800
Partial Drainage		790

Table D.14

LALBY CREEK OFF-FARM DRAINAGE COSTS

COSTS	CONTROLLED DISCHARGE [1]		UNCONTROLLED DISCHARGE
	Total Drainage [3] ($) 1985	Partial Drainage [4] ($) 1985	Partial Drainage ($) 1985
BASIN TOTAL [2]	$1,800,000	$1,800,000	$8,200,000
Cost/Acre Drained Cost/Average Section	$180 $26,600	$209 $26,600	$954 $121,300

[1] Assumes off-farm discharge is restricted to 4.0 cfs per square mile, using flow restriction at the farm boundary.

[2] Total costs do not change for total and partial drainage because of the flow restriction outlined above. The unit cost/acre of wetlands is higher for the latter case, because fewer acres of wetland are drained.

[3] Drainage of non-permanent slough/marsh, sheetwater and bog/fen.

[4] Drainage of non-permanent slough/marsh and sheetwater.

Table D.15

LALBY CREEK ON-FARM DRAINAGE COSTS

DRAINAGE SCENARIOS	BASIN AREA AFFECTED			COSTS		
	Wetland Area Drained (acres)	Grassed Ditches Area (acres)	Consolidation Pond Area Required (acres)	TOTAL (million $)	$ per average section	$ per acre drained
I. TOTAL - Drain non-permanent slough/marsh, sheetwater & bog/fen.	10,000	100	-----	1.42	21,022	142
II. PARTIAL - Drain non-permanent wetlands*	8,595	100	-----	0.61	9,031	71
III. CONSOLIDATION- Drain & consolidate non-permanent wetlands	8,595	100	400	2.97	43,969	346

* non-permanent slough/marsh and sheetwater

Table D.16

LALBY CREEK AGRICULTURAL COSTS AND BENEFITS OF DRAINAGE

FACTOR	DRAINAGE SCENARIO					
	TOTAL DRAINAGE		PARTIAL DRAINAGE		CONSOLIDATION	
	When? [1]	$ per average section	When? [1]	$ per average section	When? [1]	$ per average section
COSTS [2]						
(1) Land Area Preparation	Year 2	$11,926	Year 2	$11,248	Year 2	$11,248
	Year 3	$6,450	Year 3	$2,700	Year 3	$2,700
	Year 4	$3,571				
(2) Lost Revenue from Ditch Areas	Years 1 & 3+	$55	Years 1 & 3+	$55	Years 1 & 3+	$55
	Year 2	$158	Year 2	$158	Year 2	$158
BENEFITS						
(1) Net Revenue from drained wetland areas (crop revenues minus crop production costs)	Year 3	($84)	Year 3	($84)	Year 3	($329)
	Year 4	$1,441	Year 4	$1,378	Year 4	$1,134
	Year 5	$3,878	Year 5	$3,559	Year 5	$3,314
	Year 6	$4,882	Year 6+	$4,315	Year 6+	$4,071
	Year 7+	$5,080				
(2) Improved crop quality-transitional	Year 3	$83	Year 3	$75	Year 3	$75
	Year 4	$157	Year 4+	$139	Year 4+	$139
	Year 5+	$179				
(3) Improved crop quality - uplands	Year 2+	$472	Year 2+	$472	Year 2+	$466
(4) Improved timing	Year 4+	$1,180	Year 4+	$1,180	Year 4+	$1,164
(5) Reduced transitional area costs	Year 3	$121	Year 3	$142	Year 3	$142
	Year 4+	$229	Year 4+	$201	Year 4+	$201
(6) Improved field Efficiency	Year 3	$296	Year 3	$259	Year 3	$259
	Year 4	$564	Year 4+	$477	Year 4+	$477
	Year 5+	$641				

[1] Indicates the years in which the costs or benefits occur. A (+) sign indicates that the cost or benefit continues annually to the end of the thirty year life of the project. Drainage works are assumed to be constructed in Year 1. As is evident, some benefits do not begin immediately.

[2] Costs not shown in this table include the capital costs for drainage (See Table D.15) and the annual operation and maintenance costs which begin in Year 2.

This table is based on Tables B-1 to B-3 of Anderson (1987), p. 107-115.

Table D.17

LALBY CREEK HABITAT LOSSES FROM EACH DRAINAGE SCENARIO

Wildlife Species Group	Percent Habitat Lost: Total Drainage	Partial Drainage	Consolidation
Dabbling Waterfowl	50	24	50
Diving Waterfowl	39	19	39
Marsh Shorebirds	37	17	37
Bog/fen Shorebirds	62	37	62
Songbirds	62	37	62
Upland Game Birds	66	33	66
Ungulates	63	29	63
Open Water Furbearers	31	2	31
Marshland Furbearers	29	5	29
Ground-dwelling Wildlife	87	72	87
Average	53	28	53

Table D.18

LALBY CREEK WILDLIFE MITIGATION COSTS

Total Drainage*

Total cost	$545,773
Per Average Section	$8,074
Per Acre Drained	$55

Partial Drainage**

Total cost	$545,773
Per Average Section	$8,074
Per Acre Drained	$63

Consolidation

Total cost	$285,948
Per Average Section	$4,230
Per Acre Drained	$33

* No mitigation for bog/fen and sheetwater areas.
** No mitigation for sheetwater areas.

NOTE: Lalby Creek Mini-Basin Area = 67.6 sections (excluding Lac Magloire)

D.4 Dunvegan Creek

D.4.1 Introduction

The Dunvegan Creek drainage basin is located near Spirit River in the upper Peace River area. It discharges into the Peace just upstream from the Dunvegan Bridge. This basin has the smallest percentage of wetlands of the five studied, with only 12 percent of the land area affected, most of it non-permanent slough/marsh. Details of the wetland distribution and land use can be found in the main body of the report (Section 3.4.4) in Table 3.10, Plate 4 and Figure 3.6. The mini-basin is 55.8 sections in size.

The topography of this mini-basin is varied. The maximum elevation is approximately 2300 feet in the southwest from which it slopes towards the northeast descending a terrace slope which drops 200 feet in one mile. From here it slopes moderately to the incised channel of Dunvegan Creek. This channel dominates the physiography of the basin with over 10 percent of the basin classified as non-arable because of the steep valley sides. The eastern portion of the basin above the creek is flat table land with most of the sloughs.

The main drainage problem in the basin is the difficulty of outletting the water into the creek through very erodable soils without causing further erosion.

Most of the residents of the basin rely on surface water stored in dams and dugouts for domestic supplies, as the relatively impermeable nature of the glaciolacustrine silts and clays results in poor groundwater prospects. Any groundwater flow is expected to follow the southward dip of the bedrock.

The drainage scenarios examined in this basin are:

1. TOTAL DRAINAGE: Drain all wetlands except watercourses (3580 acres).
2. PARTIAL DRAINAGE: Drain all non-permanent wetlands (3210 acres).
3. CONSOLIDATION: Drain and consolidate non-permanent wetlands (3210 acres).

D.4.2 Hydrotechnical Aspects

The expected peak runoff from the total and partial drainage scenarios, which would have to be accommodated by an off-farm drainage network, are given in Table D.19. The capital costs, excluding operation and maintenance costs, for these works are presented in Table D.20.

D.4.3 On-Farm Drainage Engineering

Many farmers have constructed V-ditches to drain excess water to the road ditches. This has been only partially successful because the road ditches are not deep enough to provide good outlet for the drainage water. Farmers located adjacent to Dunvegan Creek also face a continuing problem

with erosion if any water is allowed to discharge over the steep banks. The capital costs for the on-farm drainage works are presented in Table D.21.

D.4.4 Soils and Agronomy

The Dunvegan Creek mini-basin lies in a well developed agricultural area producing a mixture of forage and cereal crops. About 70 percent of the basin is cultivated. The highly erosive soils in the area provide a significant challenge for those managing water.

Table D.22 summarizes the agricultural costs and benefits that were quantified in this study. These are based on an assumed schedule of installation of drainage works in year one and land preparation activities, introduction of crops and stabilization of production over a period of seven years in total.

The costs and benefits shown in Table D.22 and in Anderson (1986) were used as the basis for the final economic and financial results shown in the body of this report. They cannot be compared directly to those results since changes were made in the discount rate, the treatment of depreciation, financing and income taxes, and the base year for costs. These changes were made so that the methodology of this study would correspond exactly to that used in the Agricultural Land Base Study (MacDonald-Date, et. al., 1986; Alberta Agriculture, 1986).

D.4.5 Wildlife and Fisheries

D.4.5.1 Wildlife. The wetlands of the Dunvegan Creek mini-basin provide the greatest habitat for bog/fen shorebirds, ungulates and upland game birds. Marsh shorebirds and diving waterfowl have the least amount of habitat. The Dunvegan Creek valley provides the greatest amount of habitat for all wildlife groups. Non-permanent slough/marsh is the second most important habitat type, being best suited for the three groups above plus dabbling ducks, songbirds and small, ground-dwelling species.

Table D.23 shows the proportional habitat losses for each species group under each drainage scenario; the mitigation costs for habitat replacement are in Table D.24. The costs of 50 percent wildlife mitigation are approximately half those shown for total mitigation.

D.4.5.2 Fisheries. There is no fisheries potential in upper Dunvegan Creek or in other wetlands of the mini-basin area. All have numerous and severe limitations on sport-fish production due to the infrequency and shallowness of pools in the watercourses, low flows, or extreme flow fluctuations.

The confluence of Dunvegan Creek and the Peace River is considered to be an important fish habitat area because of spring spawning by some species, and fish use during the summer for resting and feeding. Burbot, flathead chub, lake chub and redside shiner have been collected from the creek mouth. No fish are recorded in the creek upstream of the mouth.

There are two main concerns relating to the potential fisheries impact of drainage in the Dunvegan Creek basin. These regard the negative impact on spring spawning habitat from increases in flows and suspended sediment

loads, and the loss of summer holding or feeding habitat due to sedimentation of pools and reduced streamflows.

If drainage of many small basins such as Dunvegan Creek took place the cumulative effect may well be significant for the Peace River fishery. Reductions in spring spawning habitat could affect most of the species since they are all, except bull trout, spring spawners. During the summer the creek mouths are important for resting and feeding because the Peace River does not provide many resting or holding areas for fish because of high water velocities and turbidity.

The characteristics of Dunvegan Creek, in terms of fisheries use, appear to apply to the vast majority of comparably sized watersheds entering the Peace system. This analysis, therefore, appears to be suitable for extrapolation to the entire watershed in general.

D.4.6 Economic Analysis

The results of the on-farm financial analysis are presented in Table 3.11 and for public direct benefits and costs in Table 3.12 in the main report (Section 3.4.4). Details of the breakdown of costs and benefits can be found in Anderson (1986). The costs and benefits reported by Anderson were, however, only used as the basis for the economic and financial results shown in the body of this report, as mentioned above.

Table D.19

DUNVEGAN CREEK PEAK RUNOFF

Scenario	Uncontrolled		Outflow (cfs) Controlled
Existing Conditions		1,070	
Total Drainage	2,350		1,250
Partial Drainage			880

Table D.20

DUNVEGAN CREEK OFF-FARM DRAINAGE COSTS

COSTS	CONTROLLED DISCHARGE [1]		UNCONTROLLED DISCHARGE
	Total Drainage ($) 1985	Partial Drainage ($) 1985	Partial Drainage ($) 1985
WITH ON-STREAM STORAGE			
BASIN TOTAL [2]	$6,840,000	$6,840,000	$8,900,000
Cost/ Acre Drained	$1,910	$2,131	$2,770
Cost / Average Section	$122,690	$122,690	$159,640

COSTS	CONTROLLED DISCHARGE [1]		UNCONTROLLED DISCHARGE	
	Total Drainage ($) 1985	Partial Drainage ($) 1985	Partial Drainage ($) 1985	($) 1985
WITHOUT ON-STREAM STORAGE				
BASIN TOTAL [2]	$6,300,000	$6,300,000	Partial Protection $10,900,000	Total Protection $24,600,000
Cost/ Acre Drained	$1,760	$1,960	$3,400	$7,660
Cost / Average Section	$113,000	$113,000	$195,520	$441,260

[1] Assumes off-farm discharge is restricted to 4.6 cfs per square mile, using flow restriction at the farm boundary.

[2] Total costs do not change for drainage of all or just non-permanent wetlands because of the flow restriction outlined above. The unit cost/acre of wetlands is higher for the latter case, because fewer acres of wetland are drained.

Table D.21

DUNVEGAN CREEK ON-FARM DRAINAGE COSTS

DRAINAGE SCENARIOS	BASIN AREA AFFECTED			COSTS		
	Wetland Area Drained (acres)	Grassed Ditches Area (acres)	Consolidation Pond Area Required (acres)	TOTAL (million $)	$ per average section	$ per acre drained
I. TOTAL - Drain all wetlands except watercourses	3,580	100	- - - - -	1.16	20,800	324
II. PARTIAL - Drain non-permanent wetlands	3,210	100	- - - - -	0.87	15,600	271
III. CONSOLIDATION- Drain & consolidate non-permanent wetlands	3,210	100	335	3.02	54,200	941

Table D.22

DUNVEGAN CREEK AGRICULTURAL COSTS AND BENEFITS OF DRAINAGE

FACTOR	DRAINAGE SCENARIO					
	TOTAL DRAINAGE		PARTIAL DRAINAGE		CONSOLIDATION	
	When? [1]	$ per average section	When? [1]	$ per average section	When? [1]	$ per average section
COSTS [2]						
(1)Land Area Preparation	Year 2 Year 3 Year 4	$10,691 $3,521 $258	Year 2 Year 3	$10,691 $3,521	Year 2 Year 3	$10,691 $3,521
(2) Lost Revenue from Ditch Areas	Years 1 & 3+ Year 2	$66 $192	Years 1 & 3+ Year 2	$66 $192	Years 1 & 3+ Year 2	$66 $192
BENEFITS						
(1) Net Revenue from drained wetland areas (crop revenues minus crop production costs)	Year 3 Year 4 Year 5 Year 6 Year 7+	($160) $836 $2,830 $3,840 $3,935	Year 3 Year 4 Year 5 Year 6+	($160) $836 $2,829 $3,691	Year 3 Year 4 Year 5 Year 6+	($592) $403 $2,396 $3,259
(2) Improved crop quality-transitional	Year 3 Year 4+	$117 $274	Year 3 Year 4 Year 5+	$104 $246 $264	Year 3 Year 4 Year 5+	$104 $246 $264
(3) Improved crop quality - uplands	Year 2+	$687	Year 2+	$615	Year 2+	$601
(4) Improved timing	Year 4+	$915	Year 4+	$820	Year 4+	$800
(5) Reduced transitional area costs	Year 3 Year 4 Year 5+	$169 $400 $427	Year 3 Year 4 Year 5+	$151 $359 $387	Year 3 Year 4 Year 5+	$151 $359 $387
(6) Improved field Efficiency	Year 3 Year 4 Year 5+	$99 $231 $248	Year 3 Year 4+	$99 $231	Year 3 Year 4+	$99 $231

[1] Indicates the years in which the costs or benefits occur. A (+) sign indicates that the cost or benefit continues annually to the end of the thirty year life of the project. Drainage works are assumed to be constructed in Year 1. As is evident, some benefits do not begin immediately.

[2] Costs not shown in this table include the capital costs for drainage (See Table D.21) and the annual operation and maintenance costs which begin in Year 2.

This table is based on Tables B-21 to B-23 of Anderson (1987), p. 116-120.

Table D.23

DUNVEGAN CREEK HABITAT LOSSES FROM EACH DRAINAGE SCENARIO

Wildlife Species Group	Percent Habitat Lost		
	Total Drainage	Partial Drainage	Consolidation
Dabbling Waterfowl	52	45	23
Diving Waterfowl	57	45	26
Marsh Shorebirds	62	48	29
Bog/fen Shorebirds	53	47	27
Songbirds	54	45	26
Upland Game Birds	50	43	20
Ungulates	43	38	14
Open Water Furbearers	37	29	5
Marshland Furbearers	42	32	10
Ground-dwelling Wildlife	64	58	39
Average	51	43	22

Table D.24

DUNVEGAN CREEK WILDLIFE MITIGATION COSTS

Total Drainage*

Total cost	$6,715,448
Per Average Section	$120,456
Per Acre Drained	$1,876

Partial Drainage*

Total cost	$5,617,692
Per Average Section	$100,766
Per Acre Drained	$1,750

Consolidation

Total cost	$784,102
Per Average Section	$14,065
Per Acre Drained	$244

* No mitigation for sheetwater areas.

NOTE: Dunvegan Creek Mini-Basin Area = 55.75 sections

D.5 Tee Pee Creek

D.5.1 Introduction

The Tee Pee Creek watershed is a narrow arc that stretches north and east from the Buffalo Head Hills to the confluence of the creek with the Bear River. The south end of the watershed includes the north slopes of the Buffalo Head Hills but the remainder is a broad, flat plain known as the Fort Vermilion Lowland. There are few defined channels in the basin.

The wetland composition and land use patterns of the basin are shown in Table 3.13, Figure 3.7 and Plate 5 in the main report (Section 3.4.5). This basin, in the lower Peace, demonstrates the situation in newly developing areas. Only 48 percent of the basin is cultivated and 17 percent is considered arable bush. Over half of the wetlands are classified as bog/fen. Sheetwater is a factor in the developed areas. The basin is 63 sections in size.

Existing drainage works include on-farm and road ditches and four miles of channel reconstruction at the downstream end of Tee Pee Creek. At the present time the bog/fen areas at the base of the Buffalo Head Hills absorb runoff from the hills. Farm clearing and ditching in these areas will likely reduce the ability of these bog/fen areas to absorb and attenuate the flows, thus perhaps creating problems downstream.

The drainage scenarios examined in this basin are:

1. TOTAL DRAINAGE: Drain all wetlands except watercourses (10,257 acres).
2. PARTIAL DRAINAGE: Drain all non-permanent wetlands (3052 acres).
3. CONSOLIDATION: Drain and consolidate non-permanent wetlands (3052 acres).

D.5.2 Hydrotechnical Aspects

The expected peak runoff from the total and partial drainage scenarios, which would have to be accommodated by an off-farm drainage network, are given in Table D.25. The capital costs, excluding operation and maintenance costs, for these works are presented in Table D.26.

D.5.3 On-Farm Drainage Engineering

Frequent flooding of Tee Pee Creek has been a problem for farmers adjacent to the channel. Farm drainage patterns have been greatly affected by road construction because of the flat topography in much of the basin. Farmers also use road ditches as outlets for shallow V-ditches constructed to remove excess surface water from their fields.

The capital costs to drain an average section of land using the most practical methods are presented in Table D.27.

D.5.4 Soils and Agronomy

The Tee Pee Creek mini-basin lies in a developing agricultural area producing primarily hay, barley and wheat. Drainage is carried out for two different reasons: to increase production on existing croplands that are affected by sheetwater; and to expand production through the drainage and clearing of undeveloped lands, dominated by bog/fen.

Table D.28 summarizes the agricultural costs and benefits that were quantified in this study. These are based on an assumed schedule of installation of drainage works in year one and land preparation activities, introduction of crops and stabilization of production over a period of seven years in total.

The costs and benefits shown in Table D.28 and in Anderson (1987) were used as the basis for the final economic and financial results shown in the body of this report. They cannot be compared directly to those results since changes were made in the discount rate, the treatment of depreciation, financing and income taxes, and the base year for costs. These changes were made so that the methodology of this study would correspond exactly to that used in the Agricultural Land Base Study (MacDonald-Date, et. al., 1986; Alberta Agriculture, 1986).

D.5.5 Wildlife and Fisheries

D.5.5.1 Wildlife. The wetlands of the Tee Pee Creek mini-basin provide the greatest habitat for bog/fen shorebirds, upland game birds and ground-dwelling wildlife. Marsh shorebirds and diving waterfowl have the least amount of habitat. Bog/fens provide the greatest amount of habitat for all of the wildlife groups. Tee Pee Creek and other watercourses also represent important habitat for some groups. In contrast, the other permanent wetlands, although valuable, provide only a small amount of the total habitat. Non-permanent wetlands are of marginal value to most groups and of no value to furbearers.

Table D.29 shows the proportional habitat losses for each species group under each drainage scenario; the mitigation costs for habitat replacement are in Table D.30. The costs of 50 percent wildlife mitigation are approximately half those shown for total mitigation.

D.5.5.2 Fisheries. The wetlands of the Tee Pee Creek drainage do not appear to have any fisheries potential. Tee Pee Creek may have been used for spawning and rearing by northern pike and white sucker, but channelization of the downstream reaches of the creek now precludes use by fish. Both Tee Pee Creek and the Bear River have, according to CLI rating, limited fisheries potential because of low flows, extreme flow fluctuations and low oxygen concentrations. Regional fisheries staff feel that this evaluation underestimates the value of Tee Pee Creek and, especially, the Bear River. A limited amount of research indicates that the Bear River supports good walleye and goldeye populations. The Bear River is likely used for spawning by fish from the Wabasca, and perhaps the Peace rivers, and is felt to be important for recruitment to the Wabasca River in particular.

The primary concerns involving drainage of wetlands in the Tee Pee Creek basin involve potential downstream effects on the lower reaches of the creek and the Bear River. Drainage could cause habitat destruction resulting from scour and erosion during higher peak spring flows and habitat loss during summer resulting from the premature drying of smaller tributaries and pools which serve as rearing areas for fish.

Potential impacts of drainage in the Tee Pee Creek basin on the Bear River are likely to be minor. Drainage of several wetland complexes which enter the Bear River may have major negative impacts on this river resulting from higher flood peaks and subsequent low flows. This could, therefore, result in negative impacts on the fishery resource of both the Bear and Wabasca rivers. It is felt that this analysis is representative of other muskeg-type streams in this geographic region of the province and the results could be applied to comparable drainage systems in this area.

D.5.6 Economic Analysis

The results of the on-farm financial analysis are presented in Table 3.14 and for public direct benefits and costs in Table 3.15 in the main report (Section 3.4.5). Details of the breakdown of costs and benefits can be found in Anderson (1987). The costs and benefits reported by Anderson were, however, only used as the basis for the economic and financial results shown in the body of this report, as mentioned above.

Table D.25

TEE PEE CREEK PEAK RUNOFF

Scenario	Outflow (cfs)		
	Uncontrolled		Controlled
Existing Conditions		576	
Total Drainage	1,296		736
Partial Drainage			590

Table D.26

TEE PEE CREEK OFF-FARM DRAINAGE COSTS

COSTS	CONTROLLED DISCHARGE [1]		UNCONTROLLED DISCHARGE	
	Total Drainage ($) 1985	Partial Drainage ($) 1985	Total Drainage ($) 1985	Partial Drainage ($) 1985
BASIN TOTAL [3]	**$3,960,000**	**$1,220,700**	**$11,200,000**	**$4,700,000**
Cost/ Acre Drained **Cost / Average Section**	$386 $62,900	$400 $19,400	$1,090 $177,800	$1,540 $74,600

[1] Assumes off-farm discharge is restricted to outflows of 2.9 to 3.9 cfs per square mile, using flow restriction at the farm boundary.

Table D.27

TEE PEE CREEK ON-FARM DRAINAGE COSTS

DRAINAGE SCENARIOS	BASIN AREA AFFECTED			COSTS		
	Wetland Area Drained (acres)	Grassed Ditches Area (acres)	Consolidation Pond Area Required (acres)	TOTAL (million $)	$ per average section	$ per acre drained
I. TOTAL - Drain all wetlands except watercourses	10,257	100	-----	1.14	18,100	111
II. PARTIAL - Drain non-permanent wetlands	3,052	50	-----	0.26	4,100	85
III. CONSOLIDATION- Drain & consolidate non-permanent wetlands	3,052	50	693	2.30	36,500	754

Table D.28

TEE PEE CREEK AGRICULTURAL COSTS AND BENEFITS OF DRAINAGE

FACTOR	DRAINAGE SCENARIO					
	TOTAL DRAINAGE		PARTIAL DRAINAGE		CONSOLIDATION	
	When? [1]	$ per average section	When? [1]	$ per average section	When? [1]	$ per average section
COSTS [2]						
(1) Land Area Preparation	Year 2 Year 3 Year 4	$23,533 $28,400 $10,514	Year 2 Year 3	$23,533 $11,340	Year 2 Year 3	$23,533 $11,340
(2) Lost Revenue from Ditch Areas	Years 1 & 3+ Year 2	$59 $170	Years 1 & 3+ Year 2	$29 $84	Years 1 & 3+ Year 2	$29 $84
BENEFITS						
(1) Net Revenue from drained wetland areas (crop revenues minus crop production costs)	Year 3 Year 4 Year 5 Year 6 Year 7+	($64) $301 $4,375 $8,611 $10,111	Year 3 Year 4 Year 5 Year 6+	($64) $314 $4,305 $5,898	Year 3 Year 4 Year 5 Year 6+	($480) ($102) $3,889 $5,482
(2) Improved crop quality-transitional	Year 3 Year 4 Year 5+	$48 $167 $270	Year 3 Year 4 Year 5+	$14 $49 $81	Year 3 Year 4 Year 5+	$14 $49 $81
(3) Improved crop quality - uplands	Year 2+	$594	Year 2+	$176	Year 2+	$171
(4) Improved timing	Year 4+	$395	Year 4+	$117	Year 4+	$114
(5) Reduced transitional area costs	Year 3 Year 4 Year 5+	$70 $243 $394	Year 3 Year 4 Year 5+	$21 $73 $117	Year 3 Year 4 Year 5+	$21 $73 $117
(6) Improved field Efficiency	Year 3 Year 4 Year 5+	$111 $390 $633	Year 3 Year 4+	$84 $278	Year 3 Year 4+	$84 $278

[1] Indicates the years in which the costs or benefits occur. A (+) sign indicates that the cost or benefit continues annually to the end of the thirty year life of the project. Drainage works are assumed to be constructed in Year 1. As is evident, some benefits do not begin immediately.

[2] Costs not shown in this table include the capital costs for drainage (See Table D.27) and the annual operation and maintenance costs which begin in Year 2.

This table is based on Tables B-27 to B-30 of Anderson (1987), p. 125-129.

Table D.29

TEE PEE CREEK HABITAT LOSSES FROM EACH DRAINAGE SCENARIO

Wildlife Species Group	Total Drainage	Partial Drainage	Consolidation
	Percent Habitat Lost		
Dabbling Waterfowl	100	16	6
Diving Waterfowl	100	16	5
Marsh Shorebirds	100	13	2
Bog/fen Shorebirds	100	16	7
Songbirds	100	18	9
Upland Game Birds	100	19	7
Ungulates	100	18	5
Open Water Furbearers	100	12	0
Marshland Furbearers	100	13	0
Ground-dwelling Wildlife	100	27	17
Average	100	17	6

Table D.30
TEE PEE CREEK WILDLIFE MITIGATION COSTS

Total Drainage*

Total cost	$2,833,535
Per Average Section	$45,977
Per Acre Drained	$276

Partial Drainage**

Total cost	$2,120,843
Per Average Section	$33,664
Per Acre Drained	$695

Consolidation

Total cost	$137,718
Per Average Section	$2,186
Per Acre Drained	$45

* No mitigation for bog/fen or sheetwater areas
** No mitigation for sheetwater areas

NOTE: Tee Pee Creek Mini-Basin Area = 63 sections